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DIGITAL RESTRUCTURING AND HUMAN (RE)ACTION

JUNE 26 – 29, 2022, BLED
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Andreja PUCIHAR
Mirjana KLJAJIĆ BORŠTNAR
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June 26 – 29, 2022, Bled, Slovenia

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INVITED PAPER

A Reconsideration of the Foundations of Identity Management

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Abstract There is widespread recognition that, during the process of digitalisation, much greater care is necessary in relation to the needs of individuals and society. One key area in which tensions exist is identity management. People think that their identities are intrinsic to themselves. Yet organisations represent themselves as 'provisioning' people with their 'identities'. In addition, the model of identity that organisations typically use evidences some important deficiencies. A fresh approach is needed to the model that underpins organisations' management of their relationships with people. This needs to be based on a deeper appreciation by designers of the nature of the phenomena that they seek to document and to exercise control over. A model of those phenomena is needed that is pragmatic, in the sense of fulfilling the needs of information systems (IS) practitioners and organisations, but also of the people whose data the organisation handles. It also needs to reflect metatheoretic insights. This paper presents such a model. It commences by drawing on ontology, epistemology and axiology in order to establish an outline metatheoretic model. The model is articulated, at the conceptual level and at the data modelling level. Initially, a relatively simple model is established, sufficient for inanimate objects and artefacts. The more complex requirements of humans are then addressed. It is contended that the resulting model provides a robust framework for identification and authentication in IS.

Keywords: identity, entity, metatheory, axiology.

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1 Introduction

To practitioners, an information system (IS) is a set of interacting activities by humans and artefacts that involve the handling of data. New categories of IS have progressively emerged, enabled by increases in the capacity and sophistication of IS and the information technology (IT) used to support IS. Important among them are transaction data processing (DP) systems, information systems, management information systems (MIS), decision support systems (DSS), and autonomous decision-and-action systems. The last of those categories takes advantage of the marriage of computing and communications with robotics, by including actuators that enable direct action by elements of the system on the world, and embodies the delegation of power to artefacts. Many instances are already deployed in, for example, factories, warehouses, mines and water management, and the decades of use of automated teller machines.

The effectiveness of all forms of IS depends on the extent to which the underlying model of the real world appropriately reflects the features of that world that are relevant to that particular system's purpose. Crucial among those features are the entities and identities with which the system needs to associate data. The term 'identity management' is commonly used, particularly in relation to the people whose data organisations handle, but also for inanimate objects such as stock-items and capital equipment. This aspect of IS has been important throughout the phases of eCommerce, eBusiness, eGovernment, social media, and more recently digitalisation and datafication.

This paper re-visits the problem-domains within which 'identity management' is applied. It builds on prior work in philosophy and the information systems (IS) literature. Among the wide variety of possible philosophical assumptions, an approach is selected that reflects the pragmatic world of IS practice. This is directly relevant to that portion of IS research that seeks to deliver information relevant to IS practice. Given the recent, very strong tendency within the IS discipline towards sophistication and intellectualisation, and preference for addressing other researchers rather than IS professionals, the pragmatic metatheoretic model presented here will be relevant to only a moderate proportion of IS research.

The purpose of the model is to reflect the relevant complexities, and hence to guide organisations in devising data architectures and business processes for IS that reflect real-world things and events, with a particular focus on systems in which some of the real-world things are human beings. The scope encompasses all aspects of the handling of data relating to all forms of entities and identities. Wherever possible, the model presented here uses conventional terms in conventional ways. However, many common usages of terms are ambiguous, inconsistent or unhelpful and even harmful to the effective design and operation of information systems. In these cases, terms are used in ways that are materially different from common usage, and in some cases new terms are proposed. For each term, a definition is provided that relates that term to the remainder of the framework. Once defined, all of the key terms are thereafter referred to using an initial capital. A Glossary of the defined terms is provided (Clarke 2010c).

The paper commences with an outline of the philosophical underpinnings of the analysis, comprising metatheoretic assumptions in three areas, relating to existence (ontology), knowledge (epistemology) and value (axiology). A first distinction is drawn between a real-world and an abstract-world. Within the abstract-world, the conventional approach is adopted, with two levels, one conceptual and the other concerned with data. Inanimate entities are addressed first, enabling a relatively mechanistic approach to be adopted. Human entities are then considered, which brings into play interests, rights and values, and necessitates further layers of complexity in the model.

2 A Pragmatic Metatheoretical Model

This section establishes the philosophical foundations underlying the model put forward in the later sections of the paper. The approach developed in the first paper in this series, Clarke (2021) is briefly re-presented and extended. The model is referred to as 'metatheoretic' (Myers 2018, Cuellar 2020), on the basis that it draws on relevant branches of philosophy, in particular ontology (concerned with existence), epistemology (concerned with knowledge) and axiology (concerned with value). These are key areas in which IS theorists and practitioners alike make 'metatheoretic assumptions', often implicitly, and sometimes consciously. Where the assumptions are both conscious and intentional, a more appropriate term for them is 'metatheoretic commitments'.

The model is also 'pragmatic', as that term is used in philosophy, that is to say it is concerned with understanding and action, rather than merely with describing and representing. The author's intention is instrumentalist: To achieve change in the worldviews of IS practitioners and researchers, and hence changes in behaviour and in the management of data. So the model needs to speak to IS practitioners, and to those IS academics who intend the results of their research to do the same. Figure 1 supports the textual explanations with a visual depiction of the key elements of the model.

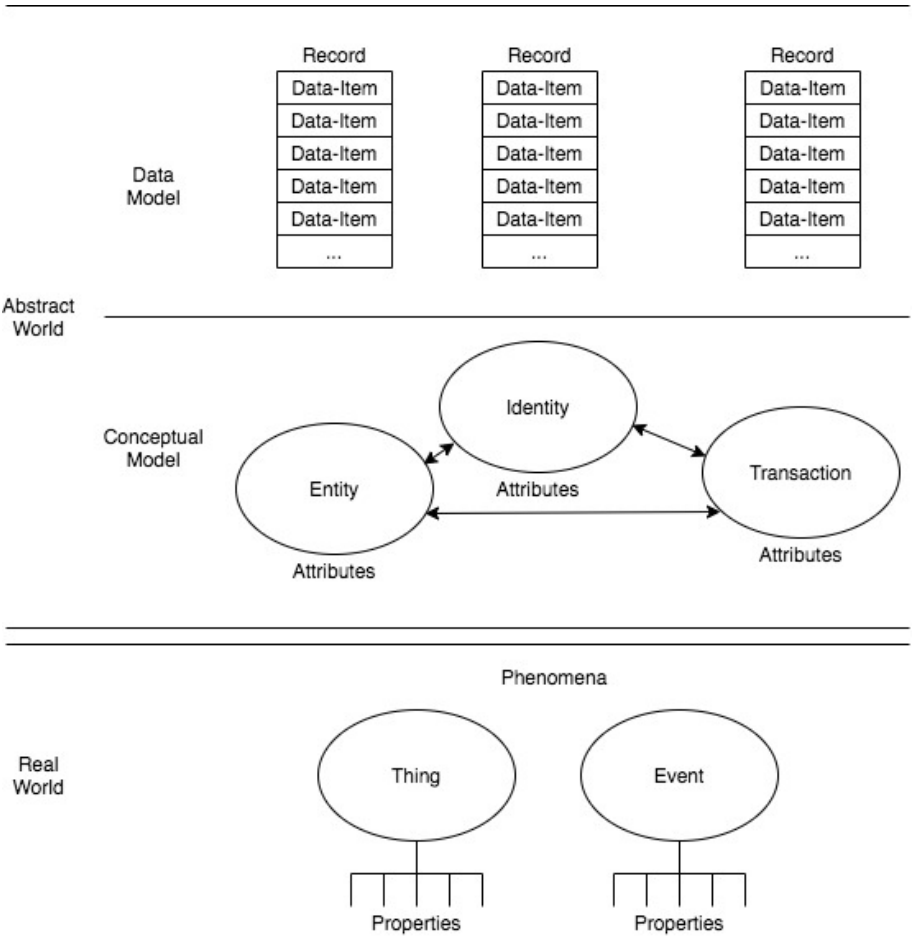


Figure 1: A Pragmatic Metatheoretical Model

2.1 Ontology

This section summarises analysis in Clarke (2021). The pragmatic approach adopted is that there is a reality, outside the human mind, where things exist – a position commonly referred to as 'realism'. Humans cannot directly know or capture those things. They can, however, sense and measure those things, create data reflecting them, and construct an internalised model of those things – an assumption related to the ontological assumption referred to as 'idealism'.

The pragmatic model adopted in this paper, and depicted in Figure 1 accordingly distinguishes a Real World from an Abstract World. The Real World comprises Things and Events, collectively Phenomena, which have Properties. These can be sensed by humans and artefacts with varying reliability. Humans create an Abstract World in which Entities are postulated that are intended to correspond to Real-World Things, and Attributes of Entities to represent the Properties of Things. Real-World Events give rise to changes in the Properties of Things, and these are reflected in the Abstract-World as Transactions that give rise to changes in Entitities' Attribute-values.

The abstract concept of an Identity, developed further below, caters for the different ways in which Entities present in different circumstances. The various kinds of Entities and Identities have Relationships with one another, represented by arrows in the depiction in Figure 1. The Relationships also have Attributes. Further discussion of these aspects of the model is provided in the following sub-sections.

In the IS field, it is necessary to adopt a flexible conception of what constitutes the Real World. This is because some of the IS that practitioners develop, maintain and operate represent imaginary Things. A design for a new IS is a model of an (as-yet) imaginary Thing. Some IS are just outline representations of an intended future IS, to enable assessment of its likely operational effectiveness, efficiency or security. Other IS create purely formal systems such as games-worlds. Another category of pseudo-Real-Worlds involves past, possible future, and even entirely hypothetical contexts, such as the Earth's atmosphere millions of years ago, or following a large-scale meteorite strike, or 50 years from now, with and without stringent measures to reduce greenhouse gas emissions. The IS profession and discipline need to be able to contribute to and support activities in such areas.

2.2 Epistemology

This section summarises analysis in Clarke (2021). Epistemology is the study of knowledge. Two contrasting conceptions of knowledge exist. The proposition of the first, 'empiricism', is that knowledge is derived from sensory experience, and is a body of facts and principles accumulated by humankind over the course of time, that are capable of being stored in the equivalent of a warehouse. This works well in circumstances where the Things represented by Entities are real rather than imaginary, and are inanimate, and their handling is largely mechanical. Examples include aircraft guidance systems and robotic production-lines.

The other, 'apriorist' view is that that knowledge is internal and personal, and the concept is not applicable outside the mind of an individual human. Within this school of thought, knowledge is the matrix of impressions within which an individual situates newly acquired information.

In order to cater for these two extremes, the term 'Knowledge' is best avoided, except when qualified by one of two adjectives:

- 'Tacit Knowledge' exists only in the mind of a particular person, is informal and intangible, and hence is not readily communicated to others. This reflects the apriorist view of epistemology; whereas
- 'Codified Knowledge' refers to Data that has been extracted from individuals' insights, and then structured, expressed and recorded in a more or less formal language (text, formulae, blueprints, procedure descriptions). It is disembodied from individuals, but is communicable among them, and hence capable of delivering a coherent body of Information to individuals in particular contexts. This reflects the empiricist view of epistemology.

A pragmatic metatheoretic approach must support modelling not only in contexts that are simple, stable and uncontroversial, but also where there is no expressible, singular, uncontested 'truth'. The pragmatic assumption adopted here is that both of those categories of philosophical theories are applicable, but in different circumstances.

In Figure 1, the Abstract World is depicted as being modelled at two levels. The Conceptual Model level endeavours to reflect the modeller's perception of the Things, the Events and their Properties, by postulating Entities and Entity-Instances, presentations of Entities called Identities, and Transactions, with Relationships of various kinds among them, all with Attributes.

The notion of an Entity corresponds to a category of Things, and Transaction to a category of Events. In the dialect used by ontologists, the term 'universal' corresponds to a category, and 'particular' refers to an instance. For example, in biology, the notion 'species' (e.g. African Elephant) is a universal, and the notion 'specimen' is a particular. An example that is perhaps more pertinent to IS is the category cargo-containers, which is a universal or Entity, whereas a specific cargo-container is a particular or Entity-Instance. The ideas and terms used in this paper, and articulated further below, are similar to, but not identical with, related ideas in the well-developed and diverse sub-discipline of conceptual modelling.

The other level, referred to here as the Data Model, enables the operationalisation of the relatively abstract ideas in the Conceptual Model level. Central to this level is the notion of 'Data'. The term, used variously as a plural and as a generic noun, refers to any quantity, sign, character or symbol, or collection of them, that is in a form accessible to a person and/or an artefact. The singular term 'datum' has fallen into disuse in recent times, and 'Data-Item' preferred. 'Real-World Data' or 'Empirical Data' is data that represents or purports to represent some Property of a Real-World Phenomenon. That is contrasted with 'Synthetic Data', which is Data that bear no direct relationship to any real-world phenomenon, such as the output from a random-number generator, or data created as a means of testing the performance of software under varying conditions.

Beyond Data, the epistemological aspects of the pragmatic model comprise assumptions made about information, knowledge and wisdom. The term 'information' is used in many ways. Frequently, even in refereed sources, it is used without clarity as to its meaning, and often in a manner interchangeable with Data. The pragmatic model adopted in this paper uses the term 'Information' for a sub-set of Data: that Data that has value. Data has value in only very specific circumstances. Until it is in an appropriate context, Data is not Information, and once it ceases to be in such a context, Data ceases to be Information.

Some people feel very uncomfortable with a definition that embodies such looseness, fuzziness and instability. Rather than a nice, straightforward 'thing', describable in mathematical terms, and analysable using formidable scientific tools, such a definition makes Information rubbery and intangible, a 'will o' the wisp'. I contend that attempts to deny that fuzziness lie at the heart of many problems in IS. By embodying in the IS profession's world-view a too-precise notion that bears little relationship with the Real-World, the modeller pre-destines the resulting IS to be a poor fit with the needs of the IS profession and the people and organisations whose needs they serve.

2.3 Axiology

This section summarises analysis in Clarke (2021). The final element of the pragmatic metatheoretic model is concerned with 'Value', in the sense of "the relative worth, usefulness, or importance of a thing" (OED II 6a). The values dominant in many organisations are operational and financial. However, many contexts arise in which there is a pressing need to recognise broader economic interests, and values on other dimensions as well.

Human values are particularly prominent in systems in which people are key players or users, and in systems that materially affect uninvolved people, usefully referred to as 'usees' (Clarke 1992, Fischer-Huebner & Lindskog 2001, Baumer 2015). Examples include people with records in shared industry databases, such as those for police suspects, tenants and insurees; and the conversation-partners of people whose voice and/or electronic communications are subjected to surveillance.

The pragmatic approach to Value recognises that:

- in some simple contexts, virtue-based evaluation (ethically or morally good/bad) may be applicable;
- in other contexts, deontic approaches are necessary, recognising an obligation, and constraining behaviour to achieve compliance with some externally-imposed norm;
- other contexts are teleologically-driven, by which is meant that the determination of appropriate actions is dependent on the degree of alignment of impacts and outcomes with the designer's purpose. A

common-denominator measure is needed, conventionally referred to as 'utility';

- in simple contexts, the only value-conflicts that arise may be between the system-sponsor's financial objectives and system-users' economic needs; and
- greater complexity arises where the assessment of utility must reflect some or all of:
    - multiple value-sets associated with many different stakeholders;
    - stakeholder interests that extend beyond economic factors to include social, environmental and political objectives;
    - intense conflict among values; and
    - solutions based on tolerance, negotiation and compromise.

3 Entities and Identities

This section defines and discusses the notions of entity and identity, which are the two central features of the pragmatic metatheoretic model adopted in this paper. It draws heavily on an earlier working paper (Clarke 2001a) and published article (Clarke 2010a, b, c, d), but re-casts the model in light of the metatheoretic discussions above. It first considers them within the Conceptual Model level, and then at the Data Model level. The notions are applied in this section to inanimate Real-World Things. The following section addresses additional considerations that arise when the Things are human beings.

3.1 (Id)Entities at the Conceptual Model Level

The conception of an entity adopted here has a great deal in common with the approach used in a wide range of conceptual modelling techniques. An 'Entity' is an element of a Conceptual Model that corresponds with a Real-World Thing. It is a category or collective notion, or a set of instances. In one sense, recognition of Things and Entities is arbitrary, because a modeller can postulate whatever they want to postulate. Generally, however, a modeller has a purpose in mind, and postulates a category judged likely to be useful in understanding some part of the Real-World, and contributing to its management.

Examples of an Entity are the sets of all cargo-containers and of all mobile-phones assigned by an organisation to its employees. Some objects comprise nested layers of objects. For example, cargo-containers may contain pallet-loads, and within that cartons, and within each carton smaller boxes. Each specific occurrence within the set of objects that makes up an Entity is an 'Entity-Instance'. Hence the Entity cargo-containers comprises many Entity-Instances, one for each particular container, and possibly many nested layers of Entity-Instances.

Each of the many specific conceptual modelling techniques has terms that correspond with those used here. In the case of the original Entity-Relationship Model of Chen (1976), an Entity corresponds with Chen's entity-set ("Entities are classified into different entity sets such as EMPLOYEE, PROJECT, and DEPARTMENT" (p.11)", and Entity-Instance has a degree of correspondence with Chen's entity: "An entity is a 'thing' which can be distinctly identified. A specific person, company, or event is an example of an entity" (Chen 1976, p.10 – but the model presented here does not treat an "event" as an Entity-Instance). An Entity may have 'Entity-Attributes', each of which is an element of a Conceptual Model that represents a Real-World Property. Containers, for example, have a colour, an owner, a type (e.g. refrigerated, or half-height), and various kinds of status (e.g. dirty or clean; and empty or loaded).

Many kinds of Entity are perceived rather differently by the modeller, depending on the context. An 'Identity' is a particular presentation of an Entity, as arises when it performs a particular role. A 'Role' is a pattern of behaviour adopted by an Entity. An Entity may adopt one Identity in respect of each Role, or may use the same Identity when performing multiple Roles.

An 'Identity-Instance' is a particular occurrence of an Identity. For example, any particular motor-vehicle is an Entity-Instance; but a motor-vehicle may at any given time be associated with an Identity-Instance, such as 'the getaway-car', 'the car carrying a person-at-risk' (e.g. the Pope), or 'the lead-vehicle in a convoy'. Another example is a single computing device, which is an Entity-Instance, supporting many processes that interact with one another and with processes running in other devices, each process being an Identity-Instance.

Whereas an Entity commonly has physical form, an Identity may have virtual form. An example of an Identity with physical form is the set of all SIM-cards inserted into mobile phones. Virtual form, on the other hand, is apparent in the case of processes running in consumer computing devices and communicating with other processes running in that or some other device. An Identity is related to the notion of role in Chen's ER Model: "The role of an entity in a relationship is the function that it performs in the relationship" (p.12).

The usage of 'Identity' in the pragmatic model presented here is very different from that attributed to the term during recent decades by most organisations. **What are commonly referred to as 'identity management' services commonly embrace the implicit assumption that Entity and Identity are the same notion or that each Entity is limited to a single Identity. This does not correspond with Real-World phenomena, and this single error in mainstream models has led to a great many difficulties in the use of 'identity management' services**. These difficulties arise with inanimate entities, but are particularly problematic where the entities are human. The term 'identity' has longstanding and widespread use by people to refer to a Real-World phenomenon evidenced by human beings, and it has subtleties that organisations have no use for, and which organisational practices have been ignoring. It is important that IS professionals and researchers, and the organisations that use IS, reflect Real-World phenomena, and respect common usage, rather than trapping themselves into misrepresentation, misunderstanding and mis-design.

An Identity may have 'Identity-Attributes', each of which is an element of a Conceptual Model that represents a Real-World Property. Whereas the colour of a car, and its make and model, are Attributes of the Entity, the dangerousness of its occupants is an Attribute associated with the Identity. Similarly, a SIM-card has different attributes from the mobile handset it is inserted into, and the processes running in a computer have different attributes from the computer that is hosting them.

A 'Transaction' is an element of a Conceptual Model that corresponds with a Real-World Event. It has Transaction-Attributes that reflect Real-World Properties that the modeller considers to be relevant to the purpose. A key function of a

'Transaction-Instance' is to give rise to a change in the state of Attributes for one or more Entity-Instances and/or Identity-Instances.

A 'Relationship' is a linkage between two elements within the Conceptual Model level. Figure 1 depicts a Relationship between an Entity and an Identity with a line ending in an arrow at each end. This applies for example to mobile-handsets and SIM-cards. Entities may also have Relationships with other Entities, and Identities with other Identities. For example, motor vehicles need to be associated with other motor vehicles under joint contracts for roadside assistance, and where they are involved in the same accident. Similarly, containers need to be associated with the organisations that own them. Organisations also own and insure motor-vehicles, and hence the two Entities organisations and motor-vehicles need to have some form of link between them.

A Relationship may have 'Relationship-Attributes'. Cardinality is a particularly important attribute. At each end of the line depicting a Relationship it may be that no Relationship exists in that direction (cardinality 0), or a single linkage (1) may be mandatory, or a range of linkages may be possible (conventionally, 'n' and 'm', or '0-n' or '1-n). For example, a cargo container must have precisely one linkage with an owner (cardinality 1), whereas the Entity that corresponds to Real-World mobile-phone-handsets may be related to multiple Identity-Instances, associated with different SIM-cards that are inserted into it, successively or even simultaneously. The arrow-head on the other end of that line reflects the fact that a SIM-card may be used in multiple, successive mobile-phone-handsets. Similarly, an Entity for motor-vehicles has a one-to-many relationship with an Identity for 'getaway-cars'. Moreover, escapees may use a succession of vehicles, each of which in turn has the Identity 'getaway-car'; so the arrow depicting this Relationship is also two-headed.

In the remainder of this article, when referring to both Entities and Identities, the abbreviation (Id)Entity is applied, and the same approach is adopted to derivative terms such as (Id)Entity-Instance.

3.2 (Id)Entities at the Data Model Level

The previous sub-section had its focus on the Conceptual Model level. The (Id)Entity notions require further articulation at the Data Model level. The terms Data, Real-World Data, Synthetic Data and Information were introduced in s.2.2 above. The pragmatic approach proposed in this paper embodies several further concepts.

In the Abstract World in which IS operate, each Attribute of an (Id)Entity is represented by a 'Data-Item', which is a storage-location in which a discrete 'Data-Item-Value' can be represented. The term 'Value', in this context, is a somewhat generalised form of "a numerical measure of a physical quantity" (OED I 4). For example, Entity-Attributes of cargo-containers may be expressed at the Data Model level as Data-Items and Data-Item-Values of Colour = Orange, Owner = MSK (indicating Danish shipping-line Maersk), Type = Half-Height, Freight-Status = Empty.

A collection of Data-Items all of which relate to a single (Id)Entity-Instance is referred to as a 'Record'. A collection of Records may be referred to as a 'File' or data-set. A Record may relate to a particular Entity-Instance (e.g. a container, or mobile handset) or to an Identity-Instance (e.g. a SIM-card), or to a Transaction-Instance. A File relates to an (Id)Entity or to a Transaction.

The term 'Metadata' refers to data that describes some attribute of other Data. Metadata may be explicitly expressed or captured, by cataloguers; or it may be automatically generated, i.e. inferred by software. It may be stored with the data to which it relates, or stored separately. During the last 2-3 decades, the term has become sufficiently widely-used that hyphenation is no longer common.

A vital question that needs to be addressed is the manner in which each individual (Id)Entity-Instance is distinguished from all of the other instances of the same (Id)Entity. Specific terms are adopted in the pragmatic metatheoretic approach proposed in this paper. The term 'Entifier' refers to any one or more Data-Items held in a Record whose value(s), alone or in combination, are sufficient to distinguish any particular Entity-Instance from all other Entity-Instances of the same Entity. The word 'entifier' is not to be found in the Oxford English Dictionary (OED),

although 'entify' is. Surprisingly (judging by the absence of prior usages found using Google Scholar), 'entifier' appears to be a neologism that I originated, first occurrence in Clarke (2001b), and first published in Clarke (2003), defined at the time as "the signifier for an entity").

Examples of single-item Entifiers include the BIC-code of a cargo-container (BIC being an abbreviation of Bureau International des Containers), the Vehicle Identification Number (VIN) of a motor-vehicle, and the International Mobile Equipment Identity (IMEI) of a mobile-phone. In some circumstances, a proxy-Entifier may be used, e.g. for a computing device, the Network Interface Card Identifier (NICId) of an Ethernet card that is installed in it.

Artefacts are usually distinguished by Entifiers that are purpose-designed, and hence comprise a single Data-Item. However, an example of a multi-data-item Entifier arises in jurisdictions that re-issue motor-vehicle registration-plates previously allocated to a now-defunct vehicle. To achieve the uniqueness that is highly desirable in an Entifier, a date-range needs to be included as part of the Entifier.

An 'Identifier' is any one or more Data-Items held in a Record whose value(s), alone or in combination, are sufficient to distinguish any particular Identity-Instance from all other Identity-Instances of the same Identity. This is a mainstream use of the term, as evidenced by Oxford English Dictionary (OED) definition 1a: "A thing used to identify someone or something".

Examples of single-item Identifiers include a code assigned by a traffic-control authority to a vehicle of interest, for example when monitoring average speed over a section of road, the Integrated Circuit Card Identification (ICCID) of a SIM-card, and a process-id (e.g. for a software agent).

In Figure 2, a visual depiction is provided of the elements of the Conceptual and Data Modelling levels defined so far in this section.

When a Real-World Event occurs, and is reflected in a Conceptual Model-level Transaction, a Record arises, whose function is to cause a change of state in one or more Attributes of one or more (Id)Entities. Means are needed to establish which

(Id)Entity-Instances are affected by the Transaction Record. This is achieved by means of (Id)Entification processes.

The term 'Identification' refers to the process whereby Data is associated with a particular Identity-Instance. This involves acquiring or postulating an Identifier that matches with previously-recorded Data-Item-Values. This application of the term is consistent with dictionary definitions, and has been used in this manner in my works since Clarke (1994c). The term has many other, loose usages, however, particularly as a synonym for 'identifier' (discussed above) or for 'token' or 'authenticator'.

An example of the Identification process in operation is the matching of a SIM-card's ICCID to an existing Record. An example of the use of a multi-Data-Item Identifier is the recognition of a vehicle on the basis of its properties (such as make, model and colour) at each end of a section of roadway over which average speed is being assessed. Another example is the use, as a proxy Identifier for a particular process running in a computing device, of the combination of a port-number and and IP-address, together with a date-time range (to allow for IP-addresses being 'dynamic', i.e. subject to being re-assigned).

The term 'Entification' refers to the process whereby Data is associated with a particular Entity-Instance. This involves acquiring or postulating an Entifier that matches with previously-recorded Data-Item-Values. The term exists in some online dictionaries and with a not unrelated meaning, but not in the OED. The term has been used consistently in my work since Clarke (2001b), but to date neither it nor, it seems, any equivalent has become mainstream.

The emergence of some such term is important, because there are material differences between Identification and Entification, variously conceptually, in terms of the Data involved, and in relation to their impacts and implications. **The failure of conventional identity management schemes to differentiate between entities and identities, and between identification and entification processes, has given rise to many IS design, deployment and operational issues.**

Examples of Entification include the matching of a particular cargo-container's BIC-Code, or a motor-vehicle's VIN, to an existing Record. In addition to such purpose-

designed Entifiers, Data-Items of convenience are often relied upon. For example, for computing devices that do not have a reliable, purpose-designed Identifier, the NICId of the Ethernet (or other) card inserted into the computing device, may be used as a proxy. An Ethernet NICId is an example of a multi-data-item Entifier, in that it comprises two Data-Items, an Organizational Unique Identifier (OUI) and a Manufacturer-Serial-No. Dependence on proxies of this nature has varying degrees of reliability.

The acquisition of the Entifier may be by observation followed by either transcription of the Data-Item-Value by a human, or alternatively by technologically-assisted means such as image-recording using a camera followed by application of optical character recognition (OCR) to extract the value. Another approach is to pre-store the Entifier in a machine-readable form, such as a barcode or a chip, and later use an appropriate technology to extract a copy of that pre-stored Data.

From an administrative perspective, (Id)Entification procedures need to be reliable and inexpensive. Achieving that aim can be facilitated by pre-recording an (Id)Entifier on a Token from which it can be conveniently captured. One common form of Token is a card, with the data stored in a physical form such as embossing, or on, or in, a recording-medium such as a magnetic stripe or a silicon chip.

This section has used the simplifying assumption that the Things underlying the (Id)Entities are inanimate, and capable of being treated as mere objects, with minimal concern about the Thing's interests and about clashes among values. The following section relaxes that assumption and considers the additional factors that arise when the underlying Things are people.

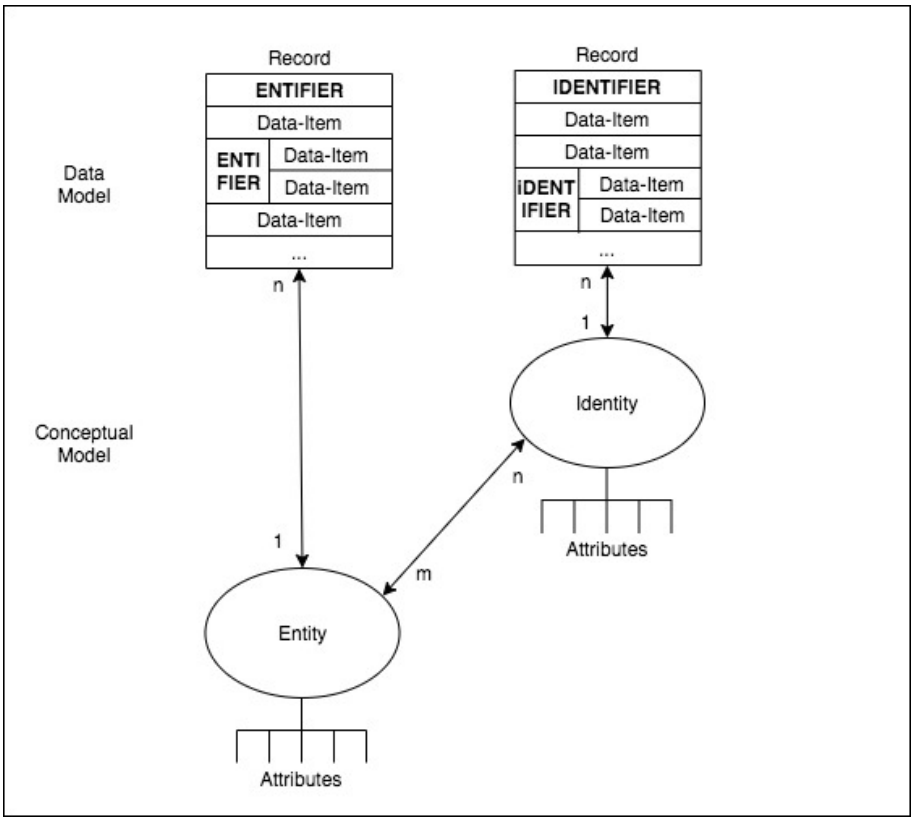


Figure 2: (Id)Entities and (Id) Entifiers

4 The Model Applied to Humans

Limiting the model's focus to inanimate objects and their representations enabled a straightforward, mechanistic approach to be adopted, and the values (axiological) aspects left in the background. In many circumstances, animals are also treated as objects. Flies and mice are variously poisoned and injected, and the impacts are rendered as Data. Cattle are entified using brands and ear-tags, and pets have chips injected. On the other hand, animal welfare constraints are placed on the handling of vertebrate animals during life and in relation to the manner of death. In some circumstances, Data is required by law to be gathered and stored, such as stocking densities for caged chickens and innoculation records, and some forms of animal slaughter are subject to monitoring and Data-recording.

Where the Entities being modelled are human beings, however, further factors come into play, and hence both the Conceptual and Data Modelling levels need to be adapted in order to reflect those factors. One consideration is the 'free will' or volitional aspect of human beings: inanimate objects do not act of their own accord, and do not have interests that influence their behaviour. In addition, values and rights loom far larger when the Entities involved are human beings. The terms 'objectification', in its sense of "the demotion or degrading of a person or class of people ... to the status of a mere object" (OED 2), and the recent terms 'digitalisation' (Brennan & Kreiss 2016), and 'datafication' (Lycett 2014) or 'datification' (Newell & Marabelli 2015), all carry a pejorative tone when used in respect of people. This is because **the mechanistic application of data-handling notions to humans involves a clash of values between administrative efficiency on the one hand and humanism on the other**. This section considers the impact on the modelling approach firstly at the conceptual and then at the data level.

4.1 The Conceptual Model Level

In section 3.1, a series of concepts was discussed and defined. The application of these concept to humans requires care. The notion of human Entity is (at least to date) uncontroversial, with Entity-Instances confined solely to specimens of the species homo sapiens. A great many Entity-Attributes are applicable specifically to human Entities. Some are physiological in nature, such as the person's hair-colour, gender, and date-of-birth or age-range. Others arise from the person's behaviour, such as their gait, how they write a signature or type a password, where they live, and their capacity to act as an agent for another Entity-Instance.

Each human Entity-Instance may present many Identity-Instances, to different people and organisations, and in different contexts. **The notion of Identity is especially important to humans, because each Entity-Instance (person) plays many roles in many contexts, and these in many cases give rise to separate Identity-Instances. Examples in economic contexts alone include seller, buyer, supplier, receiver, debtor, creditor, payer, payee, principal, agent, franchisor, franchisee, lessor, lessee, copyright licensor, copyright licensee, employer, employee, contractor, contractee, trustee, beneficiary, tax-assessor, tax-assessee, business licensor, business licensee, plaintiff,**

respondent, investigator, investigatee, and defendant. A similar richness exists in social contexts.

In many circumstances, an Identity-Instance is a presentation or role of a single, specific underlying Entity-Instance, e.g. 'I' (an Entity-Instance) am the sole 'author of this paper' (an Identity-Instance). On the other hand, some roles are filled by different people, in some cases only serially and in other cases in parallel as well. Examples of serial ambiguity include club treasurer and journal editor-in-chief, and examples of parallel ambiguity include club committee-member, journal senior editor and fire warden.

Human Identity-Attributes are related to a presentation or role, rather than reliably to a particular Entity-Instance. For example, an eConsumer has a profile comprising such features as demographics, interests, user-interface preferences and prior purchases. These Attributes may be common across some or all of the Identity-Instances a human Entity-Instance adopts; but very commonly many are not.

People performing roles in organisations inherit authorisations, permissions or privileges. While acting in their manager's absence, a person may be able to sign sick leave forms for their peers, and during an emergency, as fire warden, they can give orders to the CEO's secretary, and even the CEO. A major issue in data security and in fraud is the phenomenon of individuals abusing powers that they have by virtue of one role that they play, by applying them for extraneous purposes unrelated to that role. The Identity-Attribute commonly referred to as authorisation is accordingly very significant in many IS, and is further examined in a later paper in this series.

Transactions represent Real-World Events that give rise to changes in (Id)Entity-Attributes. Events involving humans can be both significant and sensitive, and hence considerable care is needed in the design and processing of such Transactions.

In Figure 2 above, Entities and Identities are shown as having a Relationship. The complexities of this Relationship are particularly significant where the Real World Things are humans. Relationship has a Relationship-Attribute of cardinality. Any particular Relationship-Instance may be:

- prohibited (usefully indicated by the absence of an arrow-head, or a '0' at that end of the arrow), e.g. a person under 18 is not permitted to have a driver's licence;
- mandatory and mandatorily singular ('1'), e.g. in many jurisdictions, a person may have only one spouse;
- mandatory but of any value ('1-n'), e.g. in some IS, each human Entity-Instance reflected in a Record may be required to have at least one Entifier; or
- optional and of any value ('0-n' or just 'n'), e.g. each human Entity-Instance may have any number of associated children.

Each human Entity-Instance may relate to multiple Identity-Instances (hence 'n'). Further, because many Identity-Instances can be adopted by multiple Entities (multiple fire wardens at once, multiple journal-editors in succession), the other end of the arrow is marked with an 'm' – equivalent to 'n', but implying that it is a variable independent from the 'n' at the other end of the arrow.

Subtleties in the Relationships between human Entities and Identities need to be well-understood by the designers and users of IS, and reflected in data models and business processes. A particular human Entity-Instance may strongly desire to be the only user of a particular Identity-Instance (e.g. people are very particular about who exercises the capacity to operate on their various bank accounts). Similarly, an organisation may be very concerned that a particular Identity-Instance is used only by one or more specific Entity-Instances (e.g. for the signing of contracts that bind the organisation, and for making statements to the media). **There are circumstances in which it is strongly desirable to prevent use of particular Identities by inappropriate parties. Undesirable activities of these kinds are described by such terms as impersonation, masquerade, spoofing, identity fraud and identity theft. The pragmatic model presented in this paper enables representation of these concepts. The (often implicit) models underlying some identity management schemes fail to do so.**

4.2 The Data Model Level

In section 4.2, further (Id)Entity notions were defined at the Data Model level. These too require further articulation where humans are involved. Because of the high valuation placed on human-ness, many aspects of the manner in which Data relating to inanimate objects is handled is inadequate where the Data relates to human Entities. Since c.1970, the collection and management of Data about humans has exploded under the pressures of increased organisational scale, increased social distance, and increased IT capabilities. So a great deal of public concern has arisen about the use and abuse of this Personal Data by organisations. Personal-Data-Items vary enormously in their degree of sensitivity. However, no simple formula exists for assessing sensitivity. It is dependent on individuals, their personal histories and concerns, and the contexts that they find themselves in from time to time.

The problems have been compounded by widespread, casual re-use of data for additional purposes. The meanings of data-items and their content, and the choices made in relation to data-quality, are seldom clear to the recipients. Yet more problems arise where data is drawn from multiple sources. Incompatibilities among the quality-levels and the meanings inevitably lead to inappropriate inferences.

To address the risk that the activities of government and business might be negatively affected by these public concerns, laws relating to 'personal data/information' and 'data protection' emerged. The early, largely nominal protections have proven inadequate to placate an increasingly concerned public. **Data protection laws now place considerable constraints on organisations' data-handling activities, and make considerable demands on identity management schemes. The model of (Id)Entification presented in this paper is intended to enable those challenges to be met.**

Organisations are confronted with challenges in relation to the collection, storage and use of particular Personal-Data-Items (e.g. religion, marital status, ethnicity, disability), and particular Personal Data-Item-Values (e.g. non-binary gender-choices, and gender-preferences other than hetero-sexuality). Depending on the jurisdiction, overt discrimination based on such information, even if demonstrably relevant, may be precluded by law.

Common examples of Identifiers used by or for humans include the particular name or name-variant that a person commonly uses in a particular context, such as with family, with a particular group of friends, or when working in a customer-facing role such as a prison officer, psychiatric nurse, counsellor or telephone help-desk. Names are highly variable and error-prone. They do not represent convenient Identifiers for operators of information systems, and are often supplemented by synonym-breakers, such as date-of-birth or some component of address. More effective and efficient business processes can be achieved by means of an organisation-imposed alphanumeric code, such as a customer-code or a username (Clarke 1994c). Each human Identity-Instance may themselves use many Identifiers including variants of names, and may be assigned many more Identifiers by organisations.

As discussed above, some Identifiers comprise more than one Data-Item. In rich datasets, however, a large number of multi-data-item Candidate Identifiers may be available. Examples are particularly prevalent in the kinds of data-collections about which most people feel the greatest sensitivity: health data and financial data. For example, **uniqueness can readily arise from unusual medical conditions and postcode of residence; or even place, gender and date of birth (Sweeney 2000). See also Ohm (2010) and Slee (2011). Yet it is precisely these kinds of rich data-collections that are being expropriated by governments obsessed by the 'big data' mantra, and blind to the issues of incommensurable data definitions, a-contextual applications of data, and low data-quality.**

Camouflage techniques in the form of Personal Data De-identification have been attempted, but rich data-sets are inadequately resistant to Personal Data Re-identification techniques. Personal Data Falsification is necessary if balance is to be achieved between personal values and collectivist values (Clarke 2019b).

For human entities, the primary form of Entifier is a biometric. This is a measure of some aspect of the physical person that is unique (or is claimed, or assumed, to be so). Examples include a thumbprint, fingerprints, an iris-pattern and DNA-segments. The uniqueness is not guaranteed. In theoretical terms, some biometric measures are capable of providing a very high probability of uniqueness. On the other hand, the practice of biometrics is far less reliable than theory suggests it could be, because a very substantial set of challenges have to be overcome. The literature

on biometric challenges and resulting quality is somewhat sparse, but see Mansfield & Wayman (2002) and Clarke (2002b). In some circumstances, occasional errors may matter very little and/or be easily discovered and corrected. On the other hand, some errors remain concealed, and serious consequences can arise from them, varying from psychological, social and economic harm to cases of conviction, imprisonment and even execution of the wrong person.

Another category of human Entifier is usefully referred to as an 'imposed biometric'. Examples include a brand imposed by tattooing or other techniques on a person's skin, and a unique code pre-programmed into an RFID tag that is closely associated with the person, or implanted in them (Clarke 1994b, 1997, 2001a, 2002a).

The term Nymity refers to circumstances in which the relationship between Entity and Identity is unclear. The term Anonymity refers to a characteristic of an Identity-Instance, whereby it cannot be associated with any particular Entity-Instance, whether from the data itself, or by combining it with other data. In the case of Pseudonymity, on the other hand, association of an Identity with a particular Entity may be achieved, but only if legal, organisational and technical constraints are overcome (Clarke 1999). Where either form of Nymity applies, it is inappropriate to use the term 'Identifier'. The term Pseudonym refers to a circumstance in which the association between the Identifier and the underlying Entity is not known, but in principle at least could be known. For example, a carefully-protected index may be used to sustain a link between a client-code and the name and address of the AIDS-sufferer to whom the record relates. If an Identifier cannot be linked to an Entity at all, then it is appropriately described as an Anonym. The term Nym usefully encompasses both Pseudonyms and Anonyms.

The term Pseudonym is widely used, and has a large number of synonyms (including aka, 'also-known-as', alias, avatar, character, handle, nickname, nick, nom de guerre, nom de plume, manifestation, moniker, persona, personality, profile, pseudonym, pseudo-identifier, sobriquet and stage-name). In contrast, only a small number of authors have used the term Nym, although it is readily traceable back prior to 1997. Even fewer have used the term Anonym, but it is far from unknown and I have used it consistently in my work since Clarke (2002c).

There are many circumstances in which an Identifier is unncessary and a Nym is entirely adequate. A common example is enquiries in which a set of circumstances is described by the enquirer, and a response is provided explaining the applicability of the law, or of an organisation's policies, to those circumstances. Enquiries are in many cases conducted as a single contiguous conversation. However, it is also possible for multiple, successive interactions to be connected with one another by means of a Persistent Nym, such as <meaningless-string>@gmail.com.

Identification refers to the process whereby Data is associated with a particular Identity-Instance, in this case an Identity-Instance used by a human. It involves the acquisition of an Identifier, such as a person's commnly-used name or one of their nyms, or a customer number, or a ticket-number for a particular queue. This may be provided by the person concerned, by voice or in textual form, by displaying a Token such as a membership card or a ticket, or by making a Token available that contains a pre-stored Identifier capable of being read by a device operated by an organisation.

Entification refers to the process whereby Data is associated with a particular Human Entity-Instance. This depends on the acquisition of an Entifier such as a biometric, or an imposed biometric such as an implanted chip. All forms of biometric acquisition are highly personal and threatening, and many are demeaning. For example, high-quality recording of a thumbprint or fingerprints involves a skilled operator grasping the person's wrist and controlling the hand's movement, and iris-scans and retinal-scans involve submission of the body to whatever device the measuring organisation imposes on the individual. The moderate quality of those biometric measures results in a material degree of error and hence mistaken identity. The negative impacts of those errors commonly fall on the individual. Entifiers pre-stored on a Token such as a chip-card can be captured in a technologically-assisted or -performed manner. However, that greatly increases the risk of the Entifier being associated with the wrong person.

Pastoralists have had no qualms about clipping RFID-cards onto the ears of entire herds of stock-animals. Pet-owners have accepted the injection of chips into their beloved animals because they perceive it to increase the chances of a lost pet being returned to its owner. The same approaches, however, have historically excited revulsion when applied to humans. Early applications to humans have included

chips in 'anklets' for convicts, and even remandees, in 'prisons without walls', in military 'dog-tags' to assist the identification of combat casualties, and chips injected into the bodies of staff in research facilities; but also in a few consensual contexts, such as patient-tags to assist in ensuring that operations are performed on the right person and to the right body-part; and chips injected into the bodies of customers of fashionable bars, who want a fashion-statement and/or doors to open automatically for them. On the other hand, the insertion of chips into the tooth-enamel of children to identify victims of kidnapping and abduction was not attractive to parents, and considerable concern has been expressed about entification tokens imposed on the aged. It remains to be seen whether and to what extent human values will be overridden and/or voluntarily sacrificed through this form of objectification of individuals.

IS are designed to assist organisations in administering their interactions with humans by recording Data-Item-Values for relevant (Id)Entity-Instances. The Data-Item-Values for each particular (Id)Entity-Instance are stored in a Record that contains one of more of their Entifiers or Identifiers. Data-Item-Values contained in each new Transaction can be used to locate the appropriate Record on the basis of an (Id)Entifier that the Transaction contains. Hence decisions can be made, actions taken, and amendments made to the Record for that person.

During the early decades of IS, the primary source of organisations' Data about individuals was Transactions between that organisation and the individual concerned. However, **since the late 20th century, organisations have increasingly drawn Data from multiple, additional sources, and consolidated it into individuals' Records. The reliability of the association, the potential conflicts among meanings of apparently similar Data-Items, and the nature of the original collection and subsequent handling, result in a degree of doubt about data-quality standards in such circumstances. The degree of expropriation of Personal Data has intensified enormously since the emergence of the Digital Surveillance Economy c.2005.** This commenced with the inversion of the originally user-driven World Wide Web by means of Web 2.0 technologies, and the explosion of social media and technology platforms more generally (Zuboff 2015, Clarke 2019a, Clarke 2022).

The term 'Digital Persona' refers to a model of an individual's public personality based on Data and maintained by Transactions, and intended for use as a proxy for the individual. The term is my own coinage, first presented at the Computers, Freedom & Privacy Conference in San Francisco (Clarke 1993), and published in Clarke (1994a). But it is in any case an intuitive term and has gained some degree of currency, as documented in Clarke (2014). It is quite common to see the term 'identity' used to refer to what is called here a Digital Persona; but 'identity' has many meanings, and to avoid ambiguity it is far preferable that some other term be used. Another candidate term is e-persona.

A 'Projected Digital Persona' is under the control of the individual, and is fundamental to an individual's sense of self and self-esteem. An 'Active Projected Digital Persona' is capable of taking actions as an agent for the individual. An agent may be as simple as an auto-responder to emails, or as complex as a bot that conducts social interactions intended to create and maintain a Digital Persona radically different from the individual it nominally represents. An active agent may have varying degrees of autonomy.

A Projected Digital Persona may have an 'Avatar' associated with it. This is a visual representation or embodiment of a digital persona., static or moving, which enhances, or substitutes for, an image of the (or an) underlying Entity.

An 'Imposed Digital Persona' is one controlled by someone other than the individual it is associated with. It is a model, based on data held in records and extended by transactions, which an organisation treats as an adequate impression of the Entity or Identity that it assumes the persona to represent. Under the approach adopted until the mid-twentieth century, an organisation's decisions about each individual were made by an employee local to that individual, based on available information, much of it provided at the time by the individual themselves. This exposed the organisation to the risk of uneven application of policies, and required human resources, widely dispersed. By making decisions instead on the basis of an Imposed Digital Persona, automation was facilitated, and considerable staff-savings are achieved. For individuals, **organisations' use of Imposed Digital Personae give rise to enormous social distance from the organisations they deal with, errors and inequities that are very difficult to even challenge let alone get fixed, and a great deal of dissatisfaction and frustration.**

5 Conclusions and Further Work

This paper has presented a model of the important area of entities and identities and their representation in information systems. The model is pragmatic, in that it reflects the needs of IS practitioners and researchers performing practice-relevant research, but also of those affected by IS. The model also reflects metatheoretic insights arising from the relevant branches of philosophy, reported in a predecessor article, Clarke (2021).

The notions have been introduced progressively, with definitions provided for each term, and extracted into a Glossary (Clarke 2010c). In a first pass across the territory, the simpler kinds of entities, inanimate objects and artefacts have been addressed. Further concepts have then been introduced that are necessary for IS to deal appropriately with human entities and identities.

The adoption of the model, or the re-working of existing models to take into account these key points of difference, will enable a number of weaknesses to be overcome in existing IS that assist in the management of digital personae for entities and identities. The first of these key points of difference is clear differentiation between an entity (representing a real-world physical thing), and an identity (representing a real-world virtual thing). Another is the allowance for an m:n relationship between entities and identities. These ideas lead to an appreciation of the challenges involved in appropriately associating entity-instances with identity-instances, and in appropriately associating data with an entity-instance or identity-instance. Another insight is the need to accept the existence of nymity, where an association between an identity-instance and the underlying entity-instance cannot be reliably established.

The work has laid the foundations for extensions to the basic model presented in this paper. These include the authentication of assertions of (id)entity, authorisations and access control, data and information quality, bias in organisationl decision-making, and 'fake news'. In addition to the inanimate objects, artefacts and people addressed in this paper, other categories of (id)entity are also important in IS. So-called 'incorporated' organisations are key to economic and social activities, because they enable scale and longevity. Another looming challenge for humankind is delegation to active-artefact entities including decision-and-action systems and

robots. This harbours the risk of autonomous artefacts making decisions and taking actions with direct and material effects on human beings, without any real-world entity being accountable for the decision, the action and the outcomes. Further model articulation for organisations and decision-and-action systems will be presented in subsequent papers in this series.

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DERIVING DESIGN KNOWLEDGE FOR ELEARNING COMPANIONS TO SUPPORT INTERNATIONAL STUDENTS

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Abstract International students often have difficulties in getting connected with other students (from their host country), or in fully understanding the lectures due to barriers such as interacting in a foreign language or adjusting to a new campus. eLearning Companions (eLCs) act as virtual friends, accompany students with dialog-based support for learning and provide individual guidance. We contribute to the lack of prescriptive design knowledge for that specific use case by deriving 16 design principles for eLCs and transferring them into an expository instantiation along the Design Science Research paradigm. We build upon 14 identified literature requirements and 15 condensed user requirements resulting from an empirical study with 76 Chinese-speaking exchange students at a German university. Our objective is to extend the knowledge base and support scientists and practitioners in eLC design for non-native students to initiate further research and discussion.

Keywords: pedagogical conversational, agent, learning companion, design knowledge, eLearning, design principle, international student, exchange student.

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1 Introduction

Strong internationalization efforts are finding their way into numerous curricula to prepare students for future jobs in an increasingly complex and globalized world (de Wit & Altbach, 2021; Finster & Robra-Bissantz, 2020). Over the past 50 years, international student mobility has doubled every other decade, whereby China has become the lead sending country in recent years and the US is the leading host country followed by France and Germany (de Wit & Altbach, 2021). Studying abroad offers many opportunities, such as actively experiencing a foreign culture, personal development, or knowledge enrichment (Kim & Lawrence, 2021). At the same time, however, the language barrier, lacking social relationships in the foreign country and the new learning environment also create challenges for international students. These were further exacerbated by the pandemic situation (Ezepue & Metu, 2021), as almost all teaching and learning activities had to shift to the digital space within a very short period of time, resulting in less social interaction (Grogorick & Robra-Bissantz, 2021). On the other hand, there has been rapid progress toward technically enhanced interaction through conversational agents (CAs), in form of natural-language virtual agents that support the user either voice-based (e.g., Siri) or in text-based communication as chatbots (Gnewuch et al., 2017; McTear et al., 2016). Besides their widespread use in health care, customer support, and eCommerce, CAs are also conquering the educational sector due to their easy scalability, constant availability over time, and the potential to respond individually to the learner's needs (Hobert & Meyer von Wolff, 2019). These so-called "pedagogical CAs" (PCAs) range from simple, rule-based chatbots with pure assistance functions (Hobert & Meyer von Wolff, 2019) to collaborative learning partners that act proactively and aim to establish a long-term and trusting relationship with the learner, serving as eLearning Companions (eLCs) (Grivokostopoulou et al., 2020; Kim et al., 2006).

The purpose of this paper is to first identify problems and challenges in learning during an academic stay abroad in a collaborative process with foreign exchange students from China (the world's leading country of sending out students in academia) at a German university (location of the study conducted) and to then translate these into requirements, design principles, design features and an expository instantiation of an eLC building thereupon. Thus, we address the central research question (**RQ**):

How should an eLC be designed to best support international students in learning during their stay abroad at a (German) university?

To the best of our knowledge, this particular use case of eLCs has not yet been addressed in academic literature (cf. 2.2). However, user expectations of CAs are significantly affected by the context of use (Følstad et al., 2019; van der Zandt et al., 2021). Therefore, we aim to contribute to research by introducing the potentials for the use of eLCs with nascent design knowledge derived together with international students as the future target group. We thus stimulate further research and discussion on considering eLCs to facilitate learning for non-native speakers - a potential that has high practical relevance thanks to growing internationalization efforts worldwide and urgently needed educational perspectives for an increasing number of foreign students who need effective integration into a new environment (de Wit & Altbach, 2021).

2 Methodology

In the second chapter, we introduce DSR as our methodical frame (cf. 2.1) and explain the embedded methodological approach of analyzing current literature (cf. 2.2) and the empirical online survey with the target group (cf. 2.3).

2.1 DSR as the Leading Paradigm

For IT artifacts to solve actual problems, they must be designed need-oriented, so the perspective and early involvement of potential future users is essential (van der Zandt et al., 2021). However, co-creation processes are only gradually finding their way into learning scenarios (e.g., Weinert et al., 2022). Following the approach of Khosrawi-Rad et al. (2022), we apply the DSR paradigm in a co-creation process with the target group of Chinese exchange students, to generate needs, requirements, and an implementation concept for eLCs together with and for future users. In a group of six Chinese-speaking exchange students and two researchers from a German university, we derive scientifically grounded, prescriptive design principles (Gregor et al., 2020) and an expository eLC instantiation along the DSR paradigm. Despite close monitoring of the scientific stringency in the methodological approach (*rigor*), the learners get the greatest possible freedom in setting the content focus to outline the problem to be addressed in a practice-relevant way from the perspective

of future users (*relevance*). Initially, literature requirements (LRs) are collected and complemented by user needs from an online questionnaire in Chinese language addressed to exchange students (cf. 2.3) to be then transferred into design principles (DPs) categorized along five recurring dimensions of the virtual companion canvas (Strohmann et al., 2019). These are finally instantiated in a prototypical concept for the eLC being ideated in the software *Figma*[1]. Figure 1 represents our iterative approach through the different DSR cycles (Hevner, 2007).

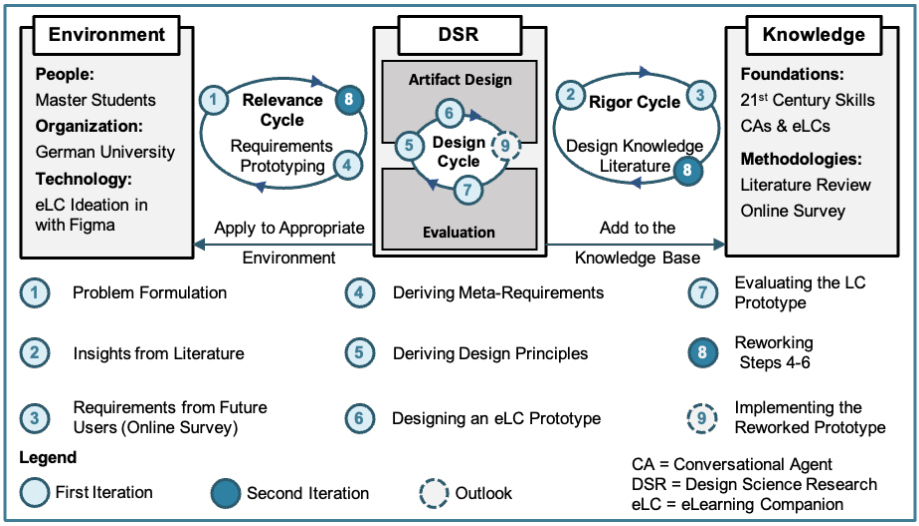


Figure 1: DSR as Leading Paradigm following Hevner (2007)

We involved international students as future users actively in the entire design process to meet their specific needs and expectations (van der Zandt et al., 2021): They shared their experiences and problem areas during their stay abroad and discussed them with other students in a seminar, actively participated in the design of the questionnaire, reflected on the derived DPs from their perspective and helped to design the prototype as co-creators (Khosrawi-Rad, Schlimbach, et al., 2022). The expository artifact was then evaluated by other, previously not involved, (international) students to check whether identified problems are tackled by the proposed solution.

[1] www.figma.com

2.2 Literature Review

We conducted a brief literature review according to vom Brocke et al. (2015) to derive literature requirements (LRs) concerning our RQ for the eLC design. In this process, the scientific databases *ACM Digital Library*, *Science Direct*, *Scopus*, *Springer Link*, *IEEE Xplore*, and *Google Scholar* were selected for their high relevance to the Information Systems discipline and queried the search term TITLE-ABS-KEY *("Learning" OR "Education" OR "E-learning" OR "Online Course") AND ("Conversational Agent" OR "Collaborative Agent" OR "Chatbot" OR "Virtual Assistant" OR "Learning Companion" OR "Relational Agent") AND ("non-native speaker" OR "Exchange student" OR "study abroad")*.

Subsequent screening of the abstracts revealed that none of the papers addressed the design of eLCs for the specific target group of (non-native speaking) exchange students, so that we had to broaden our literature search by dropping the limitation to exchange students. As a result, we drew back on current literature reviews on PCAs (Gubareva & Lopes, 2020; Hobert & Meyer von Wolff, 2019; Khosrawi-Rad, Rinn, et al., 2022) and further supportive literature to synthesize relevant design knowledge leading to LRs that we embedded into our DSR study (cf. Section 3.1).

2.3 Conducting an Online Survey

The core for the empirical survey for identifying the needs of the future target group and their requirements for supportive eLCs was an online survey conducted from Dec 10th, 2021 to Jan 10th, 2022 via the software *LimeSurvey*. The target group was Chinese-speaking exchange students since they form the largest group of foreign visiting students at a German technical university as well as in international higher education student mobility (de Wit & Altbach, 2021) and might therefore contribute valuable insights. The survey was set up in Chinese language to facilitate natural communication and contained multiple-choice questions and free text fields. We structured our survey into five categories: *demographic data* (e.g., age), *context & learning environment* (e.g., location and noise), *problem areas in learning (*e.g.*,* time management), *needs for learning support (*e.g., support in foreign language learning), and *expectations towards eLCs* (such as features and user interface). We reached out to the Chinese community of the university via personal approach, social networks, and email lists, generating 88 collected questionnaires, thereof 76 fully completed ones from the

target group. While we statistically analyzed the demographic data in *Excel*, the analysis of the free-text responses in Chinese was conducted by six native Chinese speakers in a manual peer-reviewed process within the team. In several cycles, they first extracted mentioned problem areas and expectations for eLCs, condensed the responses into key areas of joint mapping in the research team along the dimensions of the virtual companion canvas (Strohmann et al., 2019), and finally derived 15 user requirements (URs) (cf. 3.2.1).

3 Results

This chapter first derives LRs from scientific literature and URs from the online survey with the target group before transferring them into DPs to be instantiated exemplarily with concrete features in a conceptual prototype.

3.1 Deriving Literature Requirements

International students often face special challenges, so that their drop-out rates are higher compared to native German students - 45% vs. 28% (bachelor level) and 29% vs. 19% (master level) (Heublein et al., 2017). Many of them feel challenged with adapting to a new cultural context (Bethel et al., 2020; Jindal-Snape & Ingram, 2013; Li, 2017, 2019). Language barriers are a major difficulty of international students (Akanwa, 2015; Li, 2019; Wisniewski, 2018). Thus, they struggle in comprehending academic vocabulary (Li, 2019) and participating in class (Li, 2017). Chinese students' prior knowledge varies due to great curricular differences compared to the German education system (Li, 2019). This leads to difficulties in understanding and, in the worst case, to students failing exams (Li, 2019). Further challenges result from cultural differences; for example, asking critical questions and discussing with peers is rather uncommon in Chinese culture (Li, 2019). However, the problem source is often not a lack of motivation (Li, 2017, 2019), but insufficient support (Akanwa, 2015; Li, 2019).

During the literature review, it became clear that there is a variety of contributions about PCAs for digital learning in general, summarized in literature reviews (e.g., Gubareva & Lopes, 2020; Hobert & Meyer von Wolff, 2019) and foreign language learning in particular (e.g., Dokukina & Gumanova, 2020; Huang et al., 2021), but without being linked to the specific use case of supporting international students

(with language barriers). Only one paper (Obremski et al., 2021) examines verbal behavior towards PCAs which are perceived as non-native speaking in mixed-cultural settings, but without deriving design knowledge to support international students in learning. Thus, we also drew design recommendations from papers on the development of PCAs in online teaching in general, although these do not address the special case of studying abroad. Categorized according to five recurring dimensions that we mapped to the virtual companion canvas (Strohmann et al., 2019), the resulting Table 1 contains derived LRs for the eLC to be designed.

Table 1: Literature Requirements for eLCs

Dimension	Literature Requirement (LR) *The eLC should...*	Literature Source
Humanoid Design	**LR1** have a humanoid design to be perceived as a social actor that embodies a role (e.g., tutoring).	Latham (2010) Pérez Marín (2021)
	LR2 evaluate language proficiency and support non-native speakers.	Obremski et al. (2021)
	LR3 react to student's mood with emotions to build rapport.	Krassmann et al. (2018)
Communication	**LR4** interact naturally to establish a social relationship.	Hobert & Meyer von Wolff (2019)
	LR5 communicate interactively and learn permanently from users.	Pereira (2016)
Interaction	**LR6** offer relevant and high-quality user interaction to stay relevant.	Song et al. (2017)
	LR7 foster a vivid interaction via animated face-to-face interaction.	Johnson et al. (2000)
	LR8 communicate proactively to encourage learner engagement.	Wu et al. (2019)
Ethics	**LR9** build a trustworthy relationship.	Rheu et al. (2021)
	LR10 consider social & ethical values for a value-sensitive design.	Ruane (2019)
	LR11 foster autonomy, fairness, and well-being of its users.	Van de Poel (2016)
Human-Computer-Relation	**LR12** make use of AI-enhanced features for smart adaptation.	Thakore (2021)
	LR13 create room to exchange expectations and concerns to constantly improve the artifact.	Thakore (2021)
	LR14 improve learner's performance by low-intensity white noise.	Othman et al. (2019)

3.2 User Requirements from the Online Survey

Demographics: Among the 76 exchange students surveyed, 37 were male, 36 were female, and three were diverse. 55% reported being between 18 and 25 years old, another 40% were between 26 and 35 years old, and the remaining 5% did not specify. About 55% of the survey participants already graduated with a bachelor's degree. Half of the participants (38) were studying in the field of natural sciences and engineering, followed by 20 students in economics, five students in social sciences, and 13 others scattered among other fields. Almost 70% of the exchange students self-reported German language proficiency between B1 and B2 according to the European Framework of Reference (CEFR, 2001).

Context & Learning Environment: All respondents traveled to Germany to study without their families. 73% reported learning predominantly from their home and 23% chose to study in the library. The majority prefers books as a learning medium, with some respondents favoring videos. 57% say they study particularly intensively before exams and otherwise only study a little in the morning before or in the evening after lectures. These findings might be helpful to reveal locations and time frames the eLC should focus on.

Problem Areas in Learning: In order of descending frequency in the mentions, the respondents address problem areas in learning as exchange students overlapping with literature (cf. 3.1): language barriers, lack of networking with other students in the host country, lack of basic knowledge to understand the course content, speed of lectures, lack of motivation, difficulties with their time management and unfamiliar teaching and examination formats compared to the home country.

Needs for Learning Support: The survey participants repeatedly addressed the need for social interaction, support for effective and at the same time relaxed learning atmosphere, help in communicating in the foreign language, and an individualized response to their own learning needs (cf. Table 2).

Expectations of an eLC: Exchange students envision the eLC as a virtual companion that is easy to use and can be designed by the user in terms of appearance and communication style. It should help find solutions to learning tasks, link to learning resources, and facilitate interaction in German as a foreign language through

supportive functionalities. The survey revealed 15 URs for the eLC design, which are illustrated in the following Table 2.

Table 2: User Requirements for eLCs

User Requirements 1-8 *The eLC should...*	**User Requirements 9-15** *The eLC should...*
UR1 have social features to network and learn collaboratively.	**UR9** be a benevolent but not too intrusive reminder of learning.
UR2 play sounds that foster relaxation in the learning process.	**UR10** regularly update its content to stay relevant.
UR3 offer relevant and up-to-date study content.	**UR11** offer a translation feature to facilitate real-time communication.
UR4 help find literature and other relevant content to achieve learning goals.	**UR12** create a positive User Experience and Interface (UX/UI) for easy and enjoyable usage.
UR5 help improve German skills and adapts to progress made over time.	**UR13** contain both, text- and speech-based communication features.
UR6 protect personal user data.	**UR14** have adaptable avatar & voice.
UR7 help with organizing features and time management.	**UR15** adapt interaction automatically to learner's language level.
UR8 act like a friend.	

3.3 Derivation of Design Principles

Building on the 14 LIs and 15 URs, 16 DPs were derived to extend the prescriptive design knowledge to help international students overcome their problem areas in learning while studying abroad in a foreign language. The following table organizes the derived DPs along the five categories previously introduced on page 6 and extends them with a sixth dimension that forces the specifics for non-native speakers. In addition, each DP is assigned its associated LRs and URs in the back columns of Table 3.

Table 3: Design Principles for eLCs

Dimension	**Design Principle** (Designers should...)	LR	UR
Humanoid Design	**DP1** design an anthropomorphic character that can be adapted as an avatar according to the user's preferences.	1	14
	DP2 design an LC that recognizes emotions and empathizes with the user.	3	
Communi-cation	**DP3** ensure intuitive communication of the LC that adapts to the user's communication style.	4;5	3
	DP4 embed text-based or speech-based communication options to be selected.		13
Interaction	**DP5** offer relevant and high-quality content with users in online courses.	6	7;9; 12
	DP6 foster a vivid interaction via animated avatar mimic & gestures.	7	12
	DP7 design an LC that communicates proactively according to the learner's context.	8	4
Ethics	**DP8** ensure (data) security and embed privacy settings to build trust.	9	6
	DP9 consider social & ethical values when developing and implementing the LC.	10	
	DP10 foster autonomy, fairness, and well-being of its with encouraging and inclusive language and a caring attitude of the LC.	11	
Human-Computer - Relation	**DP11** make use of AI-enhanced features for real-time adaptation of the LC resources.	12	10
	DP12 encourage social interactions via features that connect students with peers.	13	1;8
	DP13 set a pleasant learning atmosphere according to the user's needs (e.g., white noise).	14	2
Specifics for Non-Native Speakers	**DP14** implement automated language level recognition and progressively adapt communication of the LC.	2	15
	DP15 offer multi-language settings and embed exercises and feedback to improve the user's foreign language skills.		5
	DP16 translate course content in real-time to support the learner in following a lecture.		11

In the next step, the still abstract DPs were transformed into concrete design features and discussed in a digital co-creation workshop with six Chinese students and the research team, resulting in an expository instantiation.

3.4 An Expository Instantiation of an eLearning Companion

Using the software *Figma*, an eLC mock-up called "*Study Buddy*" resulted as an expository instantiation. In Figure 2, selected screenshots of the conceptual prototype are shown, where the implementation of DPs 1-16 is indicated by labeling the respective **design features** (DFs).

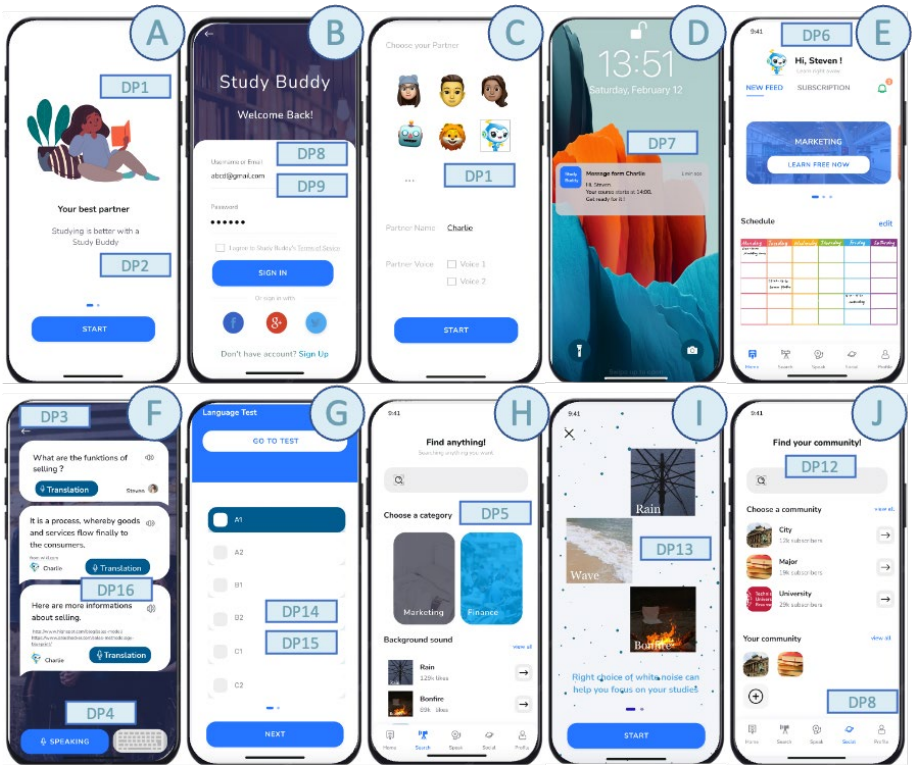


Figure 2: Prototypical Screens (A-J) of the Expository eLC

Screen A shows a human character **(DP1)** whose representation (e.g., fashion, context, and current activity) adapts to the learner based on the shared information **(DP2)** or can be further customized according to user preferences, for example, by changing the avatar and its voice **(screen C)** to represent diversity in the most non-discriminatory way possible and to enhance the learner's well-being **(DP9+10)**.

Screen B shows the encrypted, password-protected log-in of the app. In the settings, further privacy and data management choices (e.g., incognito mode, viewing and deletion functions for the user) can be selected **(DP8)**. On **screen D**, the eLC proactively reminds the user of an appointment **(DP7)**, then visualizes the timetable in **screen E** and motivates the user to study regularly with encouraging language and appropriate gestures from the avatar **(DP6)**.

Screen F shows an excerpt from an intuitive, natural language communication that determines the communication style of the learner **(DP3)** and the learner's mood in the backend (e.g., through sentiment analysis) and reacts to this in a context-based manner **(DP2)**. Thus, the eLC is perceived as a social actor with its own personality and builds a trusting relationship with the human user. The learner can communicate with the eLC both text- and speech-based **(DP4)**, with real-time translation features designed to permanently help the user follow the communication **(DP16)**. There is an automatic adjustment of the language level **(DP14)** or the users can specify it themselves **(screen G)** to initiate exercises and feedback for foreign language skill improvement **(DP15)**. **Screen H** shows learning material relevant to the user's learning goal **(DP5)**, with the associated resource library to be regularly adapted, for example, enabled by artificial intelligence **(DP11)**. A positive learning atmosphere **(screen I)** is created through selectable background noise (e.g., white noise) **(DP13)**. Different groups in a common communication space **(screen J)** encourage social networking with the peer group (e.g., with similar language level or the same major) **(DP12)** to promote collaborative learning while ensuring ethically responsible behavior and legal compliance **(DP8+9)**.

The instantiation was iteratively evaluated by presenting it to interdisciplinary researchers and other students from the host university in the form of presentations (after steps 3, 5 and 6) followed by intense discussions. Furthermore, the prototype presented here was evaluated with 16 (mainly international) students by reflecting the proposed DPs and DFs and their fit to tackle real problems in studying abroad. The versatile features met with approval, although individual design recommendations (e.g., the anthropomorphic design) were discussed controversially, similar to the literature (e.g., Feine et al., 2019; Lester et al., 1997; Moyle et al., 2019), which is why the prototype also offers non-human alternatives **(screen C)**. The DFs for overcoming the language function were rated as particularly important, with students emphasizing that incentives should be provided

to continually improve language skills - for example, through a reward system for unlocking interesting additional features. The discussion with students from different countries of origin also revealed cultural differences needing further investigation - for example, in terms of expectations of communication style (e.g., formal vs. informal) in an educational context.

4 Conclusion

In addition to a multitude of design-oriented studies on PCAs, also with a focus on language learning and the awareness that they could revolutionize digital learning, the use case of supporting foreign-language study abroad students in literature comes up short despite globally growing university internationalization efforts (de Wit & Altbach, 2021). Therefore, in our paper, we presented initial findings on how to derive actionable design knowledge for the design of eLCs to support this target group, based on scholarly literature and from the perspective of Chinese-speaking visiting students during their academic stay in Germany. We documented 14 LRs and 15 URs based on the results of an online survey with 76 surveyed Chinese students at a German university. As a result, we derived 16 DPs and classified them along the dimensions of humanoid design, communication, interaction, ethics, human-machine relationship, and specifics for non-native speakers. Our findings reveal novel insights for designing eLCs for exchange students and potentially other similar audiences. We provide researchers and practitioners with the design knowledge gained for eLCs, as documented in Tables 1-3 and the expository instantiation, so that they can ensure a problem- and user-centered development of eLCs. Furthermore, major advances in technology (e.g., NLP and ML) and internationalization intensifications in academia may encourage more exploration and implementation of these innovative eLCs (Thakore, 2021; Wu et al., 2019). We seek further instantiations and empirical evaluations of our generated design knowledge to contribute to a nascent design theory in information systems (IS). Thus, we hope to encourage designers to focus more on specific use cases of PCAs in general and eLCs with large potential user groups, such as non-native (exchange) students in particular.

However, our research is also subject to limitations. Since our goal was to derive practical DPs to support developers, the IS perspective dominates. Additionally, the empirical survey was conducted at a German university with exchange students from

one country, China, in their native language, so it is not certain whether elicited requirements are culture- and region-specific. Besides it remains unclear, whether the design knowledge is also applicable to other target groups (such as refugees integrating into new learning environments) facing some similar challenges, but also have to cope with specific ones. Therefore, the transferability and adaptation of the findings to other use cases and country combinations for the host and home country yet need to be investigated. Likewise, a different selection of literature or a differently posed questionnaire might influence the design knowledge, which is why our explicit goal is to encourage further discussion and research. Overall, our paper contributes to a better understanding of the needs of international students and how they can be supported by eLCs as a form of technology-enhanced learning in academia.

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ENSURING HIGH VALUE NATIONAL E-HEALTH SOLUTIONS USING THE BUSINESS VALUE OF IT

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Abstract This paper provides insights from a pilot study which is part of a larger longitudinal research project focused on assessing the value of different national digital health solutions. In this study, the focus is on Australia's My Health Record and the German e-Health Card. The adopted methodology is a multi-case qualitative approach which enables deeper insights to be uncovered. Data collection is from multiple sources including semi-structured interviews, surveys and the analysis of key documents. An initial model for assessing the value of the digital health solution is presented and findings are analyzed against this model to provide recommendations and understand critical success factors for designing, developing and deploying national digital health solutions.

Keywords: value based care, business value in IT, My Health record, German eHealth card.

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1 Introduction

Healthcare systems in all OECD countries are undergoing several challenges due to an ageing population, longer life expectancy and the rapid rise of chronic diseases, leading to increasing cost pressure and rising consumer expectations as well as poor patient reported outcomes (Bloomrosen and Detmer 2010; Institute of Medicine, 2001). While the use of technology to increase efficiency and transparency in organisations has been widely accepted worldwide and transformed operations in many sectors, e.g., commerce, finance or education, in health care it has been slow to date; however, now the need for technological support is becoming even more prominent in health care.

Information and communication technology (ICT) is seen as an enabler of new healthcare delivery models (Wickramasinghe and Schaffer 2010). The evolution of ICT in the healthcare industry has led to what is called e-health. The World Health Organization (2003) notes that e-health enables the leveraging of the information and communication technology to connect providers and patients and governments; to educate and inform healthcare professionals, managers and consumers; to stimulate innovation in care delivery and health system management; and to improve our healthcare system.

At this time, most OECD countries are facing similar pressures including cost pressures, COVID-19, increasing and aging population and the rise of chronic conditions. To address these challenges, they are all looking to national digital health solutions but are tackling the design, development and even deployment of these solutions very differently (Eigner et al, 2019). Moreover, even initiatives that have been established for some time eg the German e-Health Card, still struggle to support and bring together individual approaches and solutions into a national, integrated eHealth system (ibid).

Thus, it becomes essential to evaluate the business value of these solutions and identify areas for improvement as well as opportunities for more investment and advancement. The problem that faces the endeavor to study the impact of e-health solutions is apparently their complexity. In order to avoid this, we use the model of BVIT (Haddad et al., 2014) which is briefly explained before reviewing the terms "value" and 'business value" in the healthcare context and thus we answer the

research question how can we assess the business value of national e-Health solutions.

2 Value in Health Care

Porter and Teisberg (2006) define value, as a concept, as the output achieved relative to the cost incurred, suggesting that measuring value is essential to understanding the performance of any organization and driving continuous improvement. Value in healthcare can also be defined as the patient health outcomes achieved per dollar spent. Determining value and measuring it, though, depend on the perspective one uses, i.e., from a patient's perspective, healthcare values include the healthcare outcomes, quality, the safety of the delivery process, and the services associated with the delivery process. From a society perspective, benefits might include the availability of healthy and productive people who contribute to society in many ways (Porter and Teisberg 2006).

Healthcare commentary often revolves around universal availability and cost control, i.e., access and cost. People are not likely to want the lowest cost; the central issue should really be the creation of a healthcare system that provides the highest value (Rouse and Cortese 2010).

3 The Business Value of IT in Health Care

Business value of IT (BVIT) is commonly used to refer to the impact of IT on the organisational performance (Melville et al 2004). Defining the organisational performance in healthcare is different from it in other industries (Haddad et. al 2014). Cost reduction, profitability improvement, productivity enhancement, competitive advantage and inventory reduction are a number of performance measurements in other industries (Melville et al 2004). This is not the case in the healthcare industry, where organisational performance extends well beyond that to cover patient outcomes and healthcare quality (Haddad et. al 2014).

The impact of IT in health care has long been studied. Most of the current studies on this share same limitations in common: 1) looking at IT as a whole, without objectively classifying them according to agreed standards, and 2) limited scope, i.e., the impact of specific IT system on a specific outcome.

This research serves to address this gap by proposing a framework that conceptualizes the business value of IT in healthcare. This framework was designed and has been tested elsewhere (ibid). For the purpose of this paper, we will test the mapping between our framework and the national e-health initiative in Australia; namely the My Health Record. The following section summarizes the main features of this model.

4 The Conceptual Model of Business Value of IT

In order to develop a framework to evaluate the business value of IT, we first needed to classify IT systems according to their business objectives. This is the heart of the theory of IT Portfolio by Broadbent et al.(1999) who classified IT investments into four categories: Infrastructural, Transactional, Informational, and Strategic. Each of these IT systems has distinctive business objectives and different industries adopt them to different levels according to their actual needs. At the same time, we recognised the need of socio-technical aspects when studying the healthcare industry. This is obtained from the works of Rouse and Cortese (2010) that looked at the healthcare delivery from a socio-technical perspective, and divided it into four layers: the healthcare ecosystem, the system structure, the delivery operations, and clinical practices. We designed our framework by combining these two theories/frameworks together, and by performing a rigorous literature review to divide these components to build more detailed structures as Figure 1 depicts.

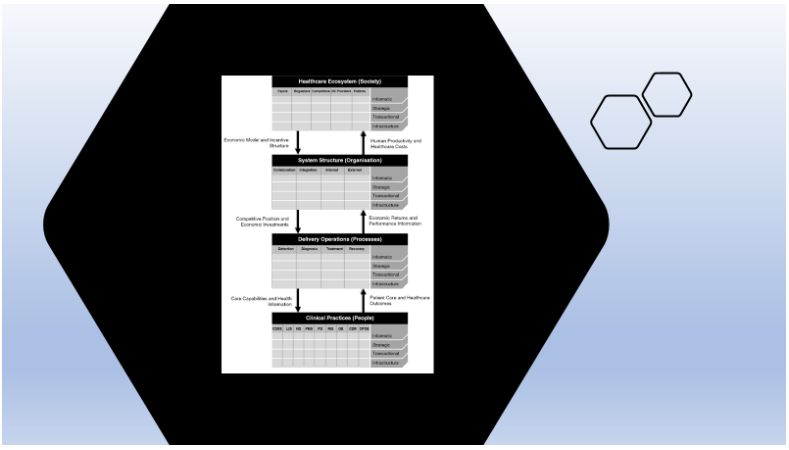


Figure 1: The Model of Business Value of IT in Health Care

5 Health Care in Australia and Germany

Both Australia and Germany provide private and government health insurance; i.e., they support a two-tier healthcare system (Eigner et al, 2019). The two-tier health insurance model in Australia is complementary (Eigner et al., 2019). This is because the public and private insurance can be taken together i.e., it is not one or the other (ibid). This contrasts with substitutive two-tier models such as the one in Germany in which one may only have one type of insurance, with a few exceptions (ibid). It is interesting to note that the majority of the population is publicly insured in both instances (ibid). Germany spends slightly more on healthcare at approximately 11.1% of GDP as compared to Australia's 9.3% (OECD, 2015; Eigner et al, 2019). Further, both countries also enjoy some of the top rates in life expectancy and quality of care (WHO Global Observatory for eHealth, 2016; Eigner et al., 2019). Finally both systems have adopted a diagnosis related grouping modelling (Eigner et al., 2019). Thus for the purposes of this study the two national e-health solutions are assed with respect to their business value.

6 My Health Record

Like all OECD countries, the Australian healthcare system is confronting major healthcare funding and delivery challenges. A further challenge relates to the fact that, even though the healthcare system in Australia has been considered highly ranked internationally because of high life expectancy and low infant mortality (Heslop 2010; Armstrong et al. 2007), this ranking is now under strain as the system is hard-pressed by an ageing population, increased prevalence of chronic disease and its burden on healthcare service, and outdated infrastructure and organisation models of healthcare delivery (Armstrong et al. 2007). In addition, healthcare inequalities also persist in Australia and the gap of service accessibility between rich and poor is widening markedly (Duckett & Willcox 2011). To address the aforementioned challenges, the Australian government decided to introduce a national e-health solution. The terminology adopted in Australia for electronic record keeping and its e-health solution is known as My Health Record (previously the Personally Controlled Electronic Health Record) which sits between an individually controlled health record and a healthcare provider health record (DoHA 2011). Thus, My Health Record has a shared use and mixed governance model (DoHA 2011).

As we can see from the preceding overview, My Health Record is a patient-centric system where technology is going to be implemented in a complex clinical and organisational environment and users are going to include a different set of stakeholders including healthcare service providers, healthcare managers, government bodies, healthcare pressure groups and most importantly patients. Further, My Health Record is a patient centric system and is a model for essentially engaging patients in their healthcare and empowering them in this undertaking. It utilizes advances in technology most notably that of web 2.0 which makes it possible to engage users by providing them interactive user interfaces.

6.1 The Evolution of My Health Record

In Australia, work on a nationally coordinated electronic health record was initiated in 1993 with the creation of National Health Information Agreement (NHIA). The primary function of NHIA was to develop a strategy and tools for better coordination between the Australian government and State and Territory governments for the collection and exchange of healthcare data and information (Bartlett, et al., 2008; NHHRC,2009). The establishment of the National Health Information Management Advisory Council (NHIMAC) resulted and occurred in 1998. A subcommittee of NHIMAC under the name of The National Electronic Health Records Task Force in 1999 in response to the House of Representatives "Health On-Line" Report was also established (Bartlett et al., 2008; Slipper & Forrest, 1997).

In 2008 (Deloitte a consulting firm was engaged to prepare a blueprint for the national strategy of eHealth development and deployment project. In 2009, the Federal government, with all State and Territory governments, announced the introduction of Health Identifiers and later in 2010 the introduction of the Health Identifiers Act to strengthen their position on the e-Health approach. Later with a budget of $AUD446.7 million dollars, the government has successfully achieved the goal of having Healthcare Identifiers (HI) services for all Australians by July 2012. The HI service includes 16-digit reference numbers for consumers and is known as the Individual Healthcare Identifier (IHI), Healthcare Providers Identifier-Individual (HPI-I) as well as Healthcare Provider Identifier-Organisation (HPI-O). This service will be common for all e-Health services like e-pathology, e-discharge summaries, e-referrals and e-medication management as well as personally

Controlled Electronic Health Record. The e-health system has now commenced and patients can be registered and they can obtain their health identifier from Medicare.

7 The German eHealth Card

Until 2004, Germany offered a basic health insurance card (KVK) providing minimum information about a patient's personal and insurance information as a credential for patients to claim health services. Due to limitations in storage and applications of this insurance card, the modernization act by the statuary health insurance in January 2004 proposed the extension of the insurance card to the electronic health card (EHC), which was finally implemented in early 2006. The goal behind the EHC was to provide health service providers access to patient information through IT to increase treatment quality, control health service processes and quality for medical treatments (GKV Spitzenverband, 2015a,b).

Since January 1st, 2015, the "Electronic Health Card (EHC)" has been mandatory credentialed in Germany to claim services covered by the health insurance (Eigner et al., 2019). The social act §291a (SGB) details the full list of required and optional information (ibid). Data security, a very sensitive and key issue follows a two-key-principle: this is essentially a public key – private key infrastructure (ibid). Although many features are yet to be implemented, the EHC is designed to include electronic patient records, medical reports, care records and medication records in the future (ibid). Table 1 presents the key aspects around interoperability, research development and uptake (European Commission, 2012; Eigner et al., 2019).

Table 1: Key aspects around interoperability, research development and uptake

Interoperability	Research Development	Uptake and Deployment
fostering EU-wide standards, interoperability testing and certification	build initiatives related to patient-centred, individual health management, as well as promote research on personal medicines	improving the education and skills of patients and health professionals
integration of processes for cross-border eHealth	develop a competitive eHealth market	guaranteeing free legal advice for business start-ups in the field of electronic health care
clarifying areas where there is legal uncertainty		measuring the added value
		International cooperation

8 User access and accessibility

To date , the eHealth acceptance rate in Germany has been hugely disappointing with a below-average increase on an EU level of 31 percent since 2007 (Eigner et al., 2019). This is particularly troubling given that over 97 percent of the insured population is now provided with an EHC (GKV Spitzenverband, 2015a; Eigner et al., 2019). Hence, a key priority moving forward is to address low acceptance.

9 Technology and infrastructure

Germany is a leading country in technology development considering financial and human resources devoted to research and development (R&D) as well as patents granted per capita (Florida et al., 2011). In health care, Germany currently ranks high considering the quality of care, access to healthcare services, efficiency and equity as well as expenditure per capita. Especially access to healthcare shows above-average results in international comparisons. Space for improvement is still found in the area of coordinated care, which constitutes a major issue to be solved by eHealth (Davis et al., 2014).

10 Key Challenges

The EHC was implemented in 2006 yet still issues around an integrated, accessible and data security compliant infrastructure for telemedical services is still not solved (Eigner et al, 2019). Through many regional projects, this challenge has tried to be addressed but as yet no suitable solution has been achieved (Dietzel, 200; Eigner et al., 20191). In addition other challenges are connected with a lack of IT standards in the healthcare sector and missing secure networks (Eigner et al., 2019). Further, lack of investments coupled with issues around liability and security also have led to massive delays (ibid).

11 Method

In order to assess the business value of these national e-health solutions, a combination of methods to collect data in a predominantly qualitative study is adopted. After securing the necessary ethics approvals, first a series of semi-structured interviews with the respective key stakeholders is conducted. In addition, a systematic review for archival records, documents and online recourses was maintained during the research project. This included published academic papers, reports, and grey literature such as, web blogs, and newspapers.
Table 2 summarizes the methods used in this study.

Table 2: The Research Design for the Purpose of this Paper

Data collection technique	**Data Source**
Semi-Structured interviews	Key stakeholders
Service Provider Qualitative Survey	GPs, specialist doctors, nurses, etc.
User group Qualitative Survey	citizens
Archival Records and Documents/On-line and Newspaper reports	Published academic papers, reports, web blogs and newspapers

12 Findings

Stage one of the analysis included an examination of the components of My Health Record and mapping them to the model of BVIT. These consisted of a combination of the basic technologies of unique identification, authentication and encryption to facilitate safe and secure method of healthcare information exchange. Mapping this comprehensive system to the IT Portfolio showed that My Health Record is mainly an informational IT system with supporting infrastructural and transactional components as well as strategic vision to transform the healthcare delivery structures in Australia. From a socio-technical perspective, My Health Record covers all components of the healthcare delivery structure in Australia. This covers the health ecosystem, health organisations, delivery operations and clinical processes. Table 3 depicts the mapping between My Health Record and the model of BVIT.

Table 3: Mapping to the Model of BVIT

	Component	**My Health Record**	**E-Health Card**
IT Portfolio	*Infrastructural*	Utilizes the Internet for information sharing. In so doing, the shared network is distributed amongst all uses. It also uses a wide range of supporting infrastructural	This is a chip card system which requires a dedicated infrastructure in clinics, doctors' offices and pharmacists to read
	Transactional	Enables patients to digitize their own health records.	Requires a public and private key system to initiate and perform transactions.
	Informational	The core functionality of My Health Record is to facilitate the exchange of digitized medical information between different stakeholders on an agreeable basis. This is facilitated by integrating patients' records entered via a dedicated web-based portal (called Consumer Portal) and the national eHealth record system. The national eHealth record system itself has a mutual information sharing structures with other different health providers.	Patient data , insurance data and medical data are stored

	Strategic	My Health Record could have a strategic nature, in terms of its role in transforming the shape of healthcare delivery in Australia. This is not the case all the time, as national e-health initiatives are now common around the world with increasing numbers of countries adopting these systems.	When the full features are implemented, then there will be e-prescribing and integration of health data to create complete health information record of the person is captured.
Healthcare Delivery	*Healthcare Ecosystem*	Patients	Patients are the central point
		Payers	The respective governments
		Regulators	The respective governments.
		Providers	Healthcare providers benefit from the system through having access to patients' records, and the ability to write on patients' records based on agreements with their patients (Consumers).
		Competitors	These are both unique systems tailored to suit the respective healthcare structures for care delivery
	System structure	My Health Record is designed to sit between an individually controlled health record and a healthcare provider via a shared governance model.	A chip card system designed to be convenient for all stakeholders
	Delivery Operations	It is hoped that using the system will improve healthcare outcomes and lead to greater efficiency and effectiveness of care delivery and fewer errors	It is hoped that using the system will improve healthcare outcomes and lead to greater efficiency and effectiveness of care delivery and fewer errors
	Clinical Practices	My Health Record is designed to present information captured from different systems to healthcare consumers and their authorized healthcare professionals according to the shared responsibilities and mixed governance model (Leslie 2011; Haddad and Wickramasinghe 2014).	The e-health card does place an extra set up burden for clinicians as they must ensure they have correct card readers installed in their offices

The way the two distinct solutions, My Health record and the e-Health Card, are structured makes them patient-centric systems. In theory, this gives the consumer (patient) a better position in shaping their care. This is vital in the light of the way healthcare is delivered to patients. One interviewee, who works closely on building better connections between patients and health providers, noted that patients normally don't have the opportunity to discuss the type of care they receive: "*we had a very long journey from where we are to where we need to be, understanding what the patient wants to get out of their visit. What product did they want? We decide on their behalf what they're going to get, largely. Even in the sittings where we discuss what they want, we don't document what they want*". It can deliver the benefit of giving the patient "*more control of who has access to their information and they can add their own bits of comments to explain their condition in details*" as another interviewee noted. It is also anticipated that the My Health Record will assist to ensure better equality of quality of care; a point of concern raised int eh Duckett report (Duckett, 2018)

The value of any IT system cannot be realised if it is not used. In order to leverage the highest potential of My health Record, 74% of the users believed incentives for the users should be introduced to start adopting the system, and 68% said that there must be an alignment between the system values and patients' values. The system must be easy to use and intuitive for 60% of the users to use the system.

13 Discussion and Conclusion

Analyses of different data collected during this research shows that My Health Record and the e-Health Card, respectively, can be classified as an informational IT system in the terminology of the theory of IT Portfolio by Weill and Broadbent (1998). According to this theory, this system, as an informational IT system, should be capable to increase control over clinical information and healthcare delivery, facilitate better information sharing between different stakeholders across the spectrum of the Australian health care, create better integration between different layers of healthcare delivery, and improve healthcare quality. The collected data demonstrate that both systems still have a long way to go before their full potential can be realised. In order to do so, a number of technological, organisational, and human requirements should be met. Once these requirements are met, the systems will have respectively better likelihood to deliver more value for different players in the web of the healthcare ecosystems for which they are supporting. The promised

values include continuity of care, less fragmented, safer, and more efficient healthcare system.

From another dimension, the results demonstrate the flexible and comprehensive nature of the model of BVIT. As sophisticated IT systems can be mapped with a large number of technological and socio-technical components to the layers of this model; this indicates that the model of BVIT is capable to be used to evaluate the business value of eHealth initiatives and programs globally according to their unique circumstances. The findings in this research extend the range and reach of the theory of IT Portfolio well beyond its current scope, which allows it to cover the complex industry of healthcare. This is enabled by adopting a socio-technical perspective when looking at the healthcare delivery, which in turn was adopted from the works of Rouse and Cortese (2010). Thus, this research examines the validity of their framework of Healthcare Delivery. According to our results, this framework seems valid and comprehensive to cover the healthcare ecosystem, the structure of healthcare organisations, the delivery operations, and the clinical practices. By their very own nature, informational IT systems are of high risk, as realising their business value is not always an easy undertaking (Weill and Broadbent 1998). From this point of view, this research has spotted a number of points that must be addressed in order to achieve the promised business value of the respective solutions. This is of high importance practically, as different players in the healthcare system share, to different levels, the same objective: having better patient outcomes by having an efficient, cost-effective, and prudent healthcare system. In conclusion, My Health Record and the e-Health Card, as informational IT systems that leverage different IT systems, have the potential to generate business value by: 1) reducing fragmentation, 2) better engaging patients in their care, 3) enhancing patient safety, and 4) increasing the efficiency of different operations in the healthcare delivery. All these promised values are subject to technological, organisational, and human requirements highlighted in this research and the subject of our follow-up studies.

As noted, this paper proffers and initial model for assessing the value of national digital health solutions. Its focus has been to being to identify the key elements that must be considered. Evaluation of such solutions also necessitates a discussion around "from whose perspective" given that many of the key stakeholders in healthcare have orthogonal goals; eg, payers want to minimise cost while patients want maximum quality. A logical approach to addressing this dilemma is to develop

a weighted average in modelling the value and this will serve to form the focus of future research. In addition, it is noted that as this is an initial model no cost benefit analysis has been embarked upon, again as the intent of this study is to first identify the key elements, future work will then focus on drilling down and identifying suitable cost benefit scenarios to include. Given this is one of the first studies of this kind, it was essential to take time and care in identifying the key components for such a model.

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FUNCTIONALITIES AND USE OF THE ZVEM PATIENT PORTAL AND THE CENTRAL REGISTRY OF PATIENT DATA

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Abstract. Introduction of eHealth is one of the key long-term goals of digitalising the public sector in Slovenia. Despite certain challenges, great progress has been made in the field of eHealth solutions. The paper presents an in-depth analysis of the functionality and use of the Patient Health Portal zVEM and the Central Registry of Patient Data (CRPD) in recent years, especially during the COVID-19 epidemic. The comprehensive methodological approach was based on the literature review, the examination of project documentation and technical specifications, the expert opinion of eHealth managers, and actual statistics from administrative and business intelligence modules. The results imply that during the epidemic the zVEM took on an important role in informing and raising public awareness. From the patient's point of view, the zVEM is certainly one of the major gains in recent decades. Accordingly, the use of the zVEM and CRPD has been growing exponentially. However, although eHealth solutions have undergone unprecedented development in recent years, much effort will have to be made by all stakeholders in the future, and additional human and material resources will have to be provided if we want to maintain progress and perhaps even accelerate the development of healthcare informatics in Slovenia.

Keywords: zVEM patient portal, Central registry of patient data, eHealth, patient summary, COVID-19, EU digital COVID certificate, digitalisation, healthcare informatics, functionality, usage.

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1 Introduction

The effective and comprehensive digital transformation of the Slovenian healthcare system is one of the fundamental changes that should contribute to greater success in dealing with the numerous challenges facing Slovenia's healthcare sector. The experiences of developed countries indicate (Bokolo, 2021; Arcury et al., 2020; Petrova, Balyka & Kachan, 2000) that successfully implemented projects of digitalising healthcare have exceptional strategic importance for the further development of the healthcare system, and they also point to broader implications centred around increased social well-being and economic growth (European Commission, 2018). The project of Slovenian healthcare digitalisation (eZdravje or eHealth), which follows the national, European and WHO guidelines, was one of the key long-term goals of the public sector in Slovenia. The entire basis of the eHealth project and the development guidelines are based on principles that were defined in the overarching document "eZdravje2010 Strategija informatizacije slovenskega zdravstvenega sistema 2005-2010" (Ministry of Health, 2005). The National Institute of Public Health (NIJZ) took over the management of the eHealth project from the Ministry of Health in 2015.

An exhaustive review of conditions in the field indicates that the difficulties encountered right from the outset in the project of digitalising Slovenian healthcare (eHealth) arose in part from the technical and technological characteristics of the existing, fragmented healthcare information systems, which are a consequence of the uncoordinated development in the area of health informatics in recent decades. On the other hand, the responsibility for the current state of affairs can be attributed principally to the decision-making authorities that left the development of healthcare informatics in this period up to individual initiatives, needs and the particular interests of individuals at the healthcare institution (or even department) level, without unified strategic guidelines for the whole country. Moreover those in charge in this period were not able to promote development and fulfil the digitalisation project through the provision of stronger political (financial, HR, organisational) support and the formulation of a modern and consistent strategy in this area.

The consequences of these factors are reflected in specific challenges that the NIJZ identified during the activities to date aimed at the universal digitalisation of Slovenian healthcare and implementation of the eHealth system, which are:

- a lack of preparedness (administrative, technological, organisational, procedural, security, etc.) of certain healthcare providers for the appropriate use of the eHealth system;
- lack of harmonisation of healthcare professionals with regard to substantive issues (e.g. the healthcare services code list, access to health documents);
- the narrow orientation of individual stakeholders towards their own professional fields and goals, without an awareness of the co-dependence of all stakeholders in the healthcare system;
- a lack of competent experts in the field of informatics at healthcare providers who could ensure adequate maintenance and operation of the eHealth system;
- inadequate funds for digitalisation of healthcare providers and for the NIJZ, which works to ensure the development, maintenance and upgrading of the central national eHealth system.

Despite these challenges, the lack of unified strategic documents and inadequate investment in the area of healthcare informatics, in the past four years great progress has been made in the development and implementation both of certain fundamental infrastructural solutions and specific eHealth user applications. In view of the dynamic of events, starting with the publication of the first strategic document in the area of digitalising healthcare in 2005, the implementation of the eHealth system, which has been carried out since the beginning of 2016, represents an important milestone, which has without doubt determined the further development of Slovenia's healthcare system. It should be noted here that despite the measurable successes of the eHealth system in the recent period, as evidenced both by national evaluations (Ministry of Public Administration, 2019) and international evaluations (European Commission, 2019), where in view of the use of eHealth Slovenia was put in sixth place, while with regard to the use of ePrescription it is in third place among EU Member States, eHealth still does not enjoy the kind of distinction that it merits.

The NIJZ has been continuously working to provide improvements and upgrades to the system. But the years 2020 and 2021 are truly special in this respect, since the COVID-19 epidemic changed the modus operandi dramatically (Stanimirović & Matetić, 2020; NIJZ, 2021a), as all the upgrades needed to be developed and implemented in the shortest possible time. Over the past two years the zVEM and the CRPD have stood out in this regard, and thus these two eHealth solutions, their

development, functionalities and use will be described in more detail and analysed below. The impact of COVID-19 on the zVEM and CRPD will be discussed in this context.

2 Methods

This paper presents an in-depth analysis of the functionalities and use of the zVEM and the CRPD, and additionally investigates how the COVID-19 epidemic has affected the development and use of the zVEM and CRPD solutions. This is an extreme example of the agile development process in the field of eHealth solutions in Slovenia, which was highly accelerated during the COVID-19 period, suggesting that the epidemic was a particular opportunity for rapid advancement in the digitalisation domain. The in-depth analysis performed in this work was based on the case study research methodology (Yin, 2018; Kljajić Borštnar, 2021), which included an in-depth study of the field and its critical analysis. On the one hand, the analysis was conducted on the basis of a literature review in the field (Tulu et al., 2021; Glöggler & Ammenwerth, 2021), and examination of project documentation and technical specifications for the zVEM and CRPD. On the other hand, it was based on the observations, experience and professional opinions of experts at the NIJZ who are managing the eHealth system (including the zVEM and CRPD), along with actual statistical data on the use of the zVEM and CRPD from the administrative and business intelligence modules (Sim & Waterfield, 2019). The selection of the research method was based on the particular features of the research field and the fact that the entire area of healthcare digitalisation in Slovenia is still in a relatively early stage, so there is just a narrow circle of experts with appropriate knowledge and understanding in this field. This methodological approach enabled both an insight into the theoretical and technological background of these kinds of digital solutions, and an empirical overview of the actual state of affairs, development stages and use of the zVEM and CRPD in the Slovenian healthcare system and in the wider social environment (Mohajan, 2018). The collaboration of experts from the NIJZ in the research enabled not just an insight into the technological/technical, statistical and administrative aspects of the operations of the zVEM and CRPD, but also an objective and thorough understanding of the user aspects, since the experts from the NIJZ are very familiar with the user experiences of patients and healthcare workers, and their satisfaction with the zVEM and CRPD. An in-depth analysis of the functionalities and use of the zVEM and CRPD, in terms

of the literature review in the field and examination of project documentation and technical specifications for the zVEM and CRPD, was conducted in the first half of 2021. Structured discussions with the NIJZ experts and the acquirement of statistical data from business intelligence and administrative modules were carried out in the period from June to December 2021.

This paper focuses on the zVEM and CRPD principally because of their usability and importance both for patients and for healthcare workers, and also because of the major progress in the past two years. The synthesis of findings from the literature, user functionalities from the technical documents, statistical reports and the views of the NIJZ experts, enable the formulation of credible conclusions based on verifiable data regarding the highlighted research aims.

3 Results

3.1 zVEM

The greatest development in terms of the digitalisation of healthcare in Slovenia in the past two years has been observed in the zVEM (health - all in one place) system (Stanimirović, 2021). The zVEM was designed as a linking service, the central hub of primary eHealth solutions for patients, for enabling secure and efficient access to their referrals, prescriptions, specialist reports and other documents, and online booking of appointments to secondary services and reviewing waiting periods (Janet & Stanimirović, 2020). From the patient's point of view, the development and establishment of the zVEM is certainly one of the major gains in recent decades (van Gemert-Pijnen, 2011). Technically the system was set up on the conclusion of the eHealth project in November 2015, while full use, with the possibility of registration, was ensured at the beginning of 2017 (Rant et al., 2018). Access to all functionalities is possible via the SI-PASS system with a digital certificate or smsPASS. The zVEM provides users with secure and reliable access to their data in the eHealth databases and access to eHealth services. It also offers users current content in the area of public health. It contains certain functionalities, online training and surveys, and also allows zVEM administrators to post important messages (Rant, Stanimirović & Žlender, 2019). First and foremost the zVEM is intended for patients, and is accessible at: https://zvem.ezdrav.si/ (NIJZ, 2021b). After logging on, users can review their data and the data of their children aged up to 15 years. They can also

sign up for notifications about prescriptions and referrals. The zVEM application for smartphones has been in use since July 2021, and this offers rapid and user-friendly access to the majority of services.

Healthcare providers send out specialist reports, discharge letters and data for the patient summary. The databases contained within the eHealth system are used to complete data on prescriptions (eRecept), referrals and appointments (eNaročanje) and vaccinations (eRCO). Insurance data is transferred from the national Health Insurance Institute (ZZZS) files. Demographic data is transferred from the Register of Patients and Spatial Units (RPPE), which is regularly updated from the Central Population Register (CRP) and the national Survey and Mapping Administration. Patients themselves can also express their consent, and can make vaccination bookings (Figure 1).

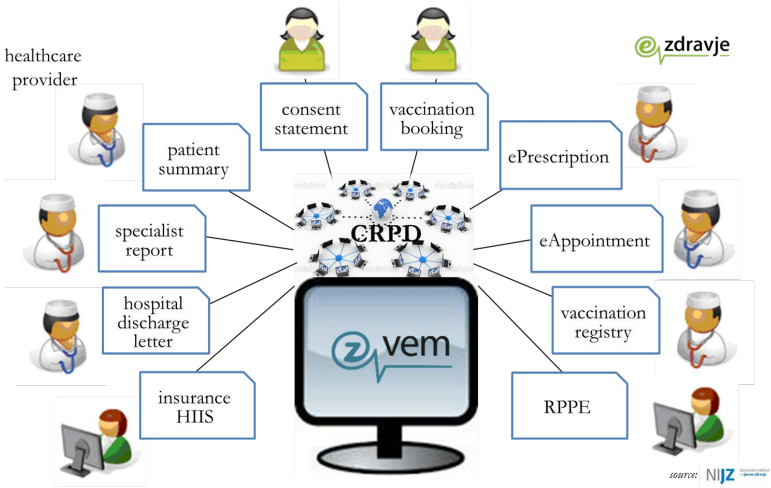


Figure 1: Display of data on the zVEM

A major added value of the system is being able to view one's own health documents. Patients can look at specialist reports and hospital discharge letters, including the results of COVID-19 testing, and they can also print out the EU Digital COVID Certificate (EU DCC; European Parliament, 2021). These documents can be viewed by attending physicians in their own information systems, and this means patients are no longer required to bring specialist reports from one healthcare provider to another.

Patients can view their patient summary for themselves and their children (aged up to 15). This is a structured record comprising the most important health data necessary for high-quality health treatment, and this is part of the CRPD.

The summary of written statements of the patient's consent contains written statements of this, and the patient can also apply a block on data being viewed.

Patients can view data on prescribed and dispensed prescription medications. For each prescription, information is given about the prescribed medication and its dispensing in pharmacies.

The patient can see their data on referrals and appointments, and make bookings for desired health services, as well as for vaccination against COVID-19. Appointments can also be cancelled using the system. Within the eAppointment (eNaročanje) service, all citizens are able to see waiting times and free slots at healthcare providers as reported by them.

3.2 zVEM plus (zVEM for healthcare providers)

The zVEM plus portal enables the capture of data and its processing, and the issuing of various reports that healthcare providers must send out. It is intended for providers that do not use their own information system for this. The investment was financed by the European Union from the European Regional Development Fund as part of the EU-wide response to the COVID-19 pandemic (Janet & Stanimirović, 2020).

3.3 Data on use of the zVEM

The zVEM was put into use successfully at the beginning of 2017, and its use experienced a major step forward in 2020 and again in 2021, with the possibility of printing out COVID-19 test results and vaccination status, along with the European Digital COVID Certificate. The first digital vaccination certificate could be printed out on 19 March 2021, while the EU Digital COVID Certificate (EU DCC) could be printed from 24 June 2021. Since 13 July 2021 the zVEM application has also been available to mobile phone users, and users have been able to download the application for verifying the EU DCC since 5 August 2021.

During the epidemic, the zVEM portal took on an important role in informing and raising public awareness. In December 2020 the portal started posting microbiological results from the CRPD, including the results of rapid and PCR tests for COVID-19. This signalled a rapid growth of users on the portal. For several years the number of registered users remained relatively low, until the portal became an important tool for obtaining documents related to health and COVID-19. A major increase was observed with the possibility of printing out the EU DCC in June 2021 and with the zVEM application for smartphones in August 2021 (Figure 2), and the number of registered users reached 409,900 in 2021.

The number of single visits to the zVEM started to grow exponentially with the introduction of test certificates and certificates of COVID-19 vaccination, and especially with the possibility of printing out the EU DCC in July 2021 (Figure 3), with a total of 23,975,212 visits recorded in 2021.

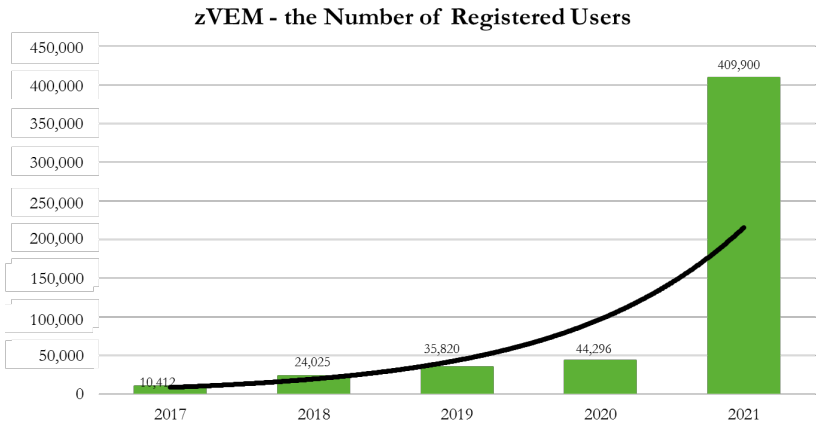


Figure 2: Growth in the number of registered users of the zVEM by year

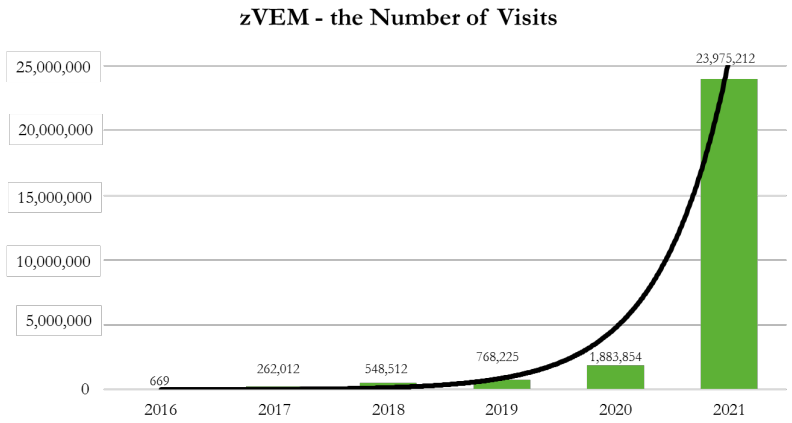


Figure 3: Growth in the number of visits to the zVEM by year

The zVEM plus (for healthcare providers) already had 101,581 users at the end of 2021.

The growth in users of the zVEM is welcome and essential for the successful development of eHealth and the connectivity of services. The fact is that the zVEM was designed six years ago, so the backup systems and databases will need upgrading if it is to be ready for the coming challenges and for the unrestricted operation of the portal in the future.

The zVEM Patient Portal surely delivers significant benefits to all stakeholders in the Slovenian healthcare system. In addition to the basic benefits of access to eHealth solutions and medical documentation already mentioned, the zVEM Patient Portal is a vital instrument for patient empowerment and directing public health initiatives and communication with the public, especially during the critical time of the COVID-19 crisis. According to the research findings, patients stressed the relevance of a sense of power and control, and thus the ability to play an active role in the entire treatment process due to the ongoing availability of their health data. In terms of the zVEM Patient Portal's involvement in public health initiatives, it has shown to be a very strong instrument with high population penetration and substantial mobilisation potential, since public trust in the information and epidemiological recommendations provided on the zVEM Patient Portal is rather high. The zVEM Patient Portal, on the other hand, allows for the interchange of

relevant medical documents among healthcare providers, alerts healthcare workers about potential patient COVID-19 infections, and so helps to reduce the incidence of these in hospitals, nursing homes, and the general public.

Other systemic benefits provided by the zVEM Patient Portal, according to participating experts, include significant financial savings, simplified and more effective procedures in terms of prescribing and dispensing medications and making patient appointments, better quality, security, and standardisation of the processed health data, and shorter waiting and consultation times between general practitioners and specialists.

3.4 CRPD

The data displayed via the zVEM is drawn from the CRPD. Today, the CRPD is the most complex public information system in the country, the eHealth database on patients with permanent or temporary residence in the Republic of Slovenia. Data is processed in the CRPD so as to enable providers to have access to data, to exchange data for providing medical care and autopsy services, and for the purpose of updating health documentation data. Access to data in the CRPD is defined in the document Pravilnik o pooblastilih za obdelavo podatkov v Centralnem registru podatkov o pacientih (Rules on authorisations for data processing in the Central Register of Patient Data, Ministry of Health, 2021a).

The CRPD comprises the RPPE, health documents and the patient summary. Demographic data in the RPPE is provided from the CRP and the national Survey and Mapping Administration. Health documents are transferred from the information systems of healthcare providers.

3.5 Data on use of the CRPD

Sending data to the CRPD is obligatory under the Health Care Databases Act (ZZPPZ, 2021), and thus all healthcare providers are required to use this system. Data is also submitted by concession holders and private operators without a concession.

Data on the number of documents in the CRPD point to a major jump in 2020 and continued exponential growth in 2021, with the figure reaching 23,975,212 (Figure 4).

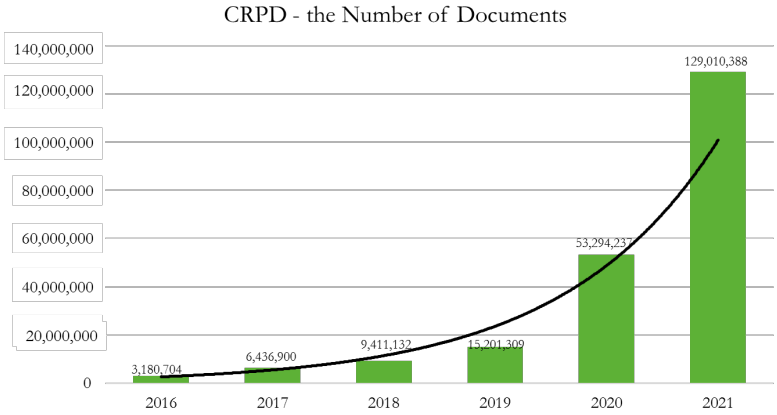


Figure 4: Growth in the number of documents in the CRPD by year

3.6 Development of new functionalities and features

The zVEM and CRPD are constantly being developed and upgraded, and while this increases their wider usability, it also inevitably increases their complexity.
All the upgrades needed to be developed and implemented in the shortest possible time. For some solutions we could use already existing ideas with adjustments, while some needed to be done from scratch. These developments would not have been possible without previous work on introducing, maintaining and developing the core services of the zVEM CRPD, and other eHealth solutions.

4 Discussion

The research results revealed that the COVID-19 epidemic had a major impact on the development and use of the zVEM and CRPD solutions. During the epidemic, use of the eHealth system grew in leaps and bounds, and in some areas increased more than tenfold (Doraiswamy, Abraham, Mamtani, & Cheema, 2020). Due to the growing requirements of users and needs of the system (patient needs, public health needs, the needs of healthcare providers, the needs of healthcare policy), numerous

existing features were upgraded, and many new solutions were developed. All this placed great pressure on the insufficient number of staff, and currently just 15 are working in the area of eHealth. This seriously impacts the eHealth budget, since upgrading and developing new services requires both initial investment costs and long-term costs for maintenance and for recruiting new staff members who will ensure the operation of these systems. The COVID-19 epidemic clearly illustrated the importance of the eHealth system for the Slovenian healthcare sector, since it can be asserted without doubt that without the eHealth system individual segments of the healthcare service in Slovenia would have collapsed (Lee and Lee, 2021), and a major portion of the system would be seriously crippled and limited in its operations. The greatest harm in such a situation would be suffered by patients (Turer et al., 2021; Guitton, 2021).

The analysis conducted in 2019 by the Ministry of Health shows that the healthcare system contains one of the largest sets of information systems in Slovenia. Various healthcare information systems are used in approximately 26 hospitals, 60 health centres and more than 1,500 clinics in the public health system. However, other countries invest on average four times as much as Slovenia in healthcare informatics. The proportion of spending on informatics relative to total income is 1% in Slovenia, while the international average is 3.9%. In 2018, according to the Hospitals Business Report there were 21,334 persons employed in all hospitals in Slovenia, of whom just 85 were IT specialists, this being 0.4% of all employees, while the international average in healthcare is 2.8%, meaning that we differ greatly in terms of professional staffing in this regard.

Data in the area of using the eHealth system is encouraging, since it points to the eHealth system becoming increasingly established in the everyday operations of the Slovenian healthcare sector, and this is indispensable in the context of an epidemic (Sust et al., 2020). In order to maintain the encouraging trend, and in the context of further development and even more effective use of the eHealth system in the future, further activities need to be implemented in the Slovenian healthcare sector.

The priority tasks in the area of eHealth are as follows:

- drawing up an eHealth strategy (including the concept of remote health or telemedicine) and overhauling the legal basis for the operation of eHealth;

- raising the level of use of the eHealth system by end users;
- improving the quality of operation of the systems, and their comprehensive maintenance and upgrading in line with identified needs and legislative requirements;
- development and implementation of new and supplementary eHealth features in line with established needs;
- allocating additional resources (material and human) for maintenance and development of central national eHealth system managed by the NIJZ, and digitalisation of the operations of healthcare providers;
- encouraging all healthcare providers to ensure complete and consistent submission of all documents and data to the CRPD (with the aim of creating and ensuring all the advantages of electronic health records);
- encouraging all healthcare providers to send accurate data on waiting periods to the central eAppointments system, and establishing info-points for patients to make appointments;
- promotion of eHealth and the opportunities offered by the eHealth system.

5 Conclusion

Since the completion of the project in 2015 the eHealth system in Slovenia has undergone unimagined development. This development has been particularly intense during the COVID-19 epidemic. Some experts even claim that health informatics has advanced as much in the last two years as it would have advanced in ten years under normal circumstances. It is not just the systems that have developed, but their use has also increased more than tenfold. This in turn has brought up difficulties that have arisen to a large extent due to the inadequate investment in informatics, both in terms of HR and infrastructure, and also with regard to developing existing and new systems. The system was also very much exposed to the poor digital literacy of users, including the most basic use of computer and telecommunications equipment, as well as computer and information literacy and the use of software systems themselves.

The digital culture in healthcare institutions needs to be raised, along with the digital competence of all employees. Digital culture is also important for the close cohesion of informatics and other areas of work in organisations, eliminating the traditional divergence. Here, the digital competence of all employees is very important.

In short, major efforts will be needed, as well as funds, to maintain and continue the truly huge progress made in healthcare informatics in recent years.

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Physical Activity Application Supporting Young Elderly: Insights for Personalization

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Abstract Digital wellness technologies, such as physical activity applications, are potential solutions in promoting physical activity among young elderly. In this study, we qualitatively analyzed how can a physical activity application enable a more personalized support for physical activity among young elderly. As a result of our thematic analysis, we identified three different categories that represent the central wishes and needs of young elderly for physical activity applications to enable a more personalized support: 1) More holistic data collection that combines physical activity data and health-related data, 2) Sharing the physical activity data with healthcare professionals, and 3) Tracking small acts of everyday life. We suggest that these findings can increase the understanding on the viewpoint of young elderly and provide insights to be used in the design of personalized digital wellness services and products in the future.

Keywords: personalization, digital wellness, physical activity, young elderly, physical activity application.

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1 Introduction

The global population is ageing and practically all countries are undergoing a growth in the proportion of their older population. This, together with the improving life expectancy at older ages (United Nations, 2019), makes supporting healthier ageing an increasing priority area for healthcare and policy providers. One way to support healthier aging is through physical activity. Physical activity and exercise have significant health benefits and contribute to the prevention of non-communicable diseases (WHO, 2020), they aid in maintaining the ability to function when ageing and help to protect against age-related illness and frailty (Hoogendijk et al., 2019). Despite the well-established benefits of physical activity and the research-based recommendations, insufficient physical activity is a major global problem among ageing populations (WHO, 2020). For example, in Finland, where this study was conducted, only around one fourth of the people over 60 years of age meet the national recommendations for physical activity (Finnish Institute for Health and Welfare, 2019). Hence, it is crucial to investigate solutions that could support physical activity among older populations.

Digital wellness technologies, that is, "digital technologies that can be used to support different aspects of wellness" (Kari et al., 2021) are seen as prospective solutions. Their potential to promote physical activity among older populations has been suggested in several studies (e.g., Seifert et al., 2017; Stockwell et al., 2019). However, in terms of digital wellness technology use, older populations have distinct needs and challenges (Kari et al., 2020). Therefore, research that taps into the wishes and needs of this population is much required.

To address this need, this study investigates what kind of support a physical activity application, a commonly used digital wellness technology, can provide for physical activity among older populations. More precisely, the emphasis is on the *young elderly* age group, which consist of people aged approximately 60–75 years. The needs in this group can greatly vary from those of younger users and also from those of oldest-old users. However, even though the wishes and needs of young elderly can vary comparing to younger populations, their viewpoint has not gained much attention in research related to design of digital services (Carlsson & Walden, 2019). The specific focus of this study therefore lies in analyzing the wishes and needs young elderly particularly have for personalization enabled by a physical activity

application. We ask the following research question: How can a physical activity application enable a more personalized support for physical activity among young elderly? To gain understanding on the phenomenon, a focus group was conducted with a group of young elderly. The collected data was thematically analyzed. Our findings provide insights for scholars by increasing the understanding on the viewpoint of young elderly regarding the personalized support of physical activity applications. They also provide insights for practitioners to be used in the design of personalized digital wellness services for young elderly.

2 Digital Wellness Technology and Personalization

Digital wellness technologies have been found potential in promoting physical activity and exercise among older populations, albeit with certain limitations. For example, in studies focusing on older populations, Muellmann et al. (2018) found that eHealth interventions can be effective in promoting physical activity, at least in the short term. Similarly, Yerrakalva et al. (2019) found that mobile health application interventions can be effective in promoting physical activity in the short term. Kari et al. (2021), in a 12-month follow-up study, found a physical activity application use to promote a modest increase in physical activity levels. Larsen et al. (2019) found that physical activity monitor-based interventions have a moderate effect on physical activity. Changizi and Kaveh (2017) found that mHealth technology can improve several wellness outcomes such as physical activity and related self-efficacy. Despite the positive findings, older populations have also been found to encounter various challenges when taking digital wellness technologies, such as physical activity applications, into use and during the use (Kari et al., 2020).

Personalization has gained a lot of attention in the field of digital wellness technologies (e.g., Ali et al., 2016; Korhonen et al., 2017). Broadly put, personalization refers to the process in which the service provider tailors services and products to meet with the needs of the user (Tuzhilin, 2009). In the context of digital technologies, the design of personalization has typically followed two main approaches: either digital technology is used to presuppose user's needs and automatically match services with these needs or alternatively users are provided options to choose from to have a personalized service (Lee et al., 2015). Examples of personalized services enabled by digital technologies are different forms of recommendations, adaptive information, or customized user interfaces (Cena et al.,

2018). A practical example of personalized services enabled by digital technologies would be activity trackers that are capable to aggregate and process different forms of data on the user to provide personalized user experiences (e.g., Fitbit, n.d).

More recently, scholars have also investigated personalization in the entire service process, focusing not only on a single digital technology, but more broadly on the role of digital technologies in service level personalization. This means that instead of solely focusing on technical components, the aim is to understand the support digital technologies can provide for service personalization (Korhonen & Isomursu, 2017; Korhonen et al., 2020). In service level personalization the support from digital technologies can vary from fully automated support for personalization to different forms of data visualizations and decision aids that can support the service provider, but also the user to personalize services in collaboration (Korhonen & Isomursu, 2017). More specifically, the support can vary from aiding the service provider, such as a healthcare professional in detecting and understanding the user's condition, to the use of aggregated data in reaching a shared understanding with the user regarding the potential interventions and their impact (Korhonen et al., 2020). In other words, the data aggregation and data visualization can enable the healthcare professional to review the data from digital technologies together with the healthcare user, to evaluate the impact, and also to provide more personalized support, such as personal advice or more detailed interpretation to the data (Tong et al., 2021).

As older populations are a highly heterogeneous group of people, who may have varying skill levels, needs, and challenges concerning the use of digital wellness technologies (Kari et al., 2020), the design of physical activity applications should consider these individual wishes and needs. As they also have varying physical activity conditions, the health and wellness context addresses the importance of personalization by default (Monteiro-Guerra et al., 2020). In this study, we analyze how can a physical activity application enable a more personalized support for physical activity among a particular user group of young elderly. We believe that the understanding of their viewpoint can provide insights to be used in the design of more personalized digital wellness services and products that would be more aligned with their wishes and needs.

3 Research Methods

The study was part of a *DigitalWells* research program (2019-2022), in which young elderly participants took a mobile physical activity application into use. The program and the present study were conducted in Finland, and the participants were recruited via the Finnish pensioners' associations. No limits except for age were set for partaking. The participants used a physical activity application in their everyday life and conducted physical activity according to their own preferences. That is, they were not provided with any specific exercise programs to follow or goals to reach out for, but instead could freely conduct exercise how and when they preferred. The application use was free of charge for the participants, but an own smartphone was required. The local ethical committee was consulted before the start of the research program, which deemed that no separate approval was required for the conducted studies. All participants also gave a written informed consent.

3.1 Physical Activity Application Used in the Study

The application was developed for the young elderly target group in the *DigitalWells* research program. The application operates on the Wellmo application platform (Wellmo, 2021), where the application features constitute their own entity. Wellmo supports iOS and Android operating systems. The central features are related to tracking everyday physical activity and exercise. These include, for example, features for tracking and following the conducted physical activities and exercises, as well as weekly, monthly, and annual reports on the conducted physical activity and exercise. It is also possible to import data from external services supported by the Wellmo platform, such as Google Fit, Apple Health, and Polar Flow.

3.2 Data Collection and Analysis

To understand the wishes and needs of young elderly for personalization, a qualitative research approach was followed. The empirical data was collected by using a focus group interview. Focus group interview is an interview with a small group of people on a specific topic and it allows participants to present their own viewpoints while also reflecting their viewpoints while hearing others' responses (Patton, 2005). Focus group was selected as a method as it enabled us to investigate and analyze the needs and wishes young elderly have for personalization enabled by

a physical activity application described in their own words. The focus group was conducted in November 2021 with a group of young elderly who had participated to the research program. In the focus group, all the participants had at least one year experience of partaking in the research program, and they could therefore be considered to be highly familiar with the physical activity application at the time of the focus group interview.

The focus group interview included questions from three main themes. First theme was about exercise habits in general, including motivation to exercise and to remain physically active as well as whether the physical activity levels had changed after starting in the research program. The second theme was about the role and support the physical activity application provides for physical activity and exercise. Third theme was about the wishes and needs for personalization enabled by the physical activity application, including the support that the physical activity application could provide through personalization. These themes were interconnected and selected to gain understanding on how the physical activity application currently supports exercise but also to explore that how it could provide a more personalized support in the future, based on the experience of young elderly. In the focus group, one of the authors was moderating the interview and took field notes using pen and paper. The focus group was also audio recorded and transcribed afterwards. As the focus group was done in Finnish, all the quotes presented in the Findings are our translations.

The focus group interview was conducted with seven participants, and it lasted for 43 minutes. All participants were young elderly, including five females and two males with the average of 73 years. All of them stated to be using the application frequently and to be regular exercisers. The demographic information of the participants is summarized in Table 1.

Table 1: Focus group participant demographics

Participant	Gender	Age
1	Female	76
2	Female	70
3	Female	72
4	Male	75
5	Male	73
6	Female	70
7	Female	72

The data analysis focused on the wishes and needs of young elderly with the aim to provide insights to be used in the design of more personalized services and products. This was done through a thematic analysis. More precisely, the collected data was analyzed thematically with an aim to identify, analyze, and report themes within the data (Vaismoradi et al., 2013). The data analysis process was inductive by its nature (Patton, 2005), where one of the authors carried out the familiarization and analysis of the data. Themes were identified through recognizing elements young elderly used in describing their wishes and needs. These themes were refined to come up with thematic categories that were discussed between authors. Based on these discussions we concluded with three main categories, which represent the central wishes and needs young elderly have for physical activity applications to enable a more personalized support.

4 Findings

This section presents the findings of our thematic analysis process, that is, the three main categories that represent the central wishes and needs of young elderly for physical activity applications to enable a more personalized support. The three categories are: 1) More holistic data collection that combines physical activity data and health-related data, 2) Sharing the physical activity data with healthcare professionals, and 3) Tracking small acts of everyday life.

4.1 More holistic data collection that combines physical activity data and health-related data

The participants considered that it would be important to be able to combine the physical activity data aggregated in the application with other health related measurements they did daily. This would provide a more holistic data aggregation that would represent their overall health condition better. This means that many of the participants did also other measurements besides physical activity (using the physical activity application but also paper-based records), for example, keeping track of their blood pressure and heartrate levels. They did these measurements regularly and were eager to combine these measurement results with their physical activity data in order to see, for example, had there been any changes not only in their physical activity levels but also in their health condition in more general. One participant highlighted this through an example of using heartrate data in estimating the recovery from a physical activity:

" I do measure my blood pressure regularly and report it also to here [application]. Then also heartrate, when I walk the stairs that how long does it take to recover. I measure these to myself". (1)

Another participant highlighted that he used different types of measurements for both physical activity levels but also more health-related elements, such as blood-pressure. He wished to be able to connect these different types of measurement results to gain a more holistic understanding of his condition, as illustrated below:

" In addition to these pie charts, there are also different measurements one can use [in the application]. I find it interesting to connect physical activity levels into health-related information, such as the monitoring of blood pressure." (5)

In overall, the idea to combine physical activity data with more health-related data was discussed by the participants when they considered the value the physical activity application could provide them in the future. All were keen to report their physical activity levels, some more than others, but the idea to gain a more holistic understanding by combining this data with the health-related information was seen interesting.

4.2 Sharing the physical activity data with healthcare professionals

The participants considered that the use and sharing of physical activity data with healthcare professionals would be welcomed for personalization. In the focus group, the participants wished they could show their physical activity levels for healthcare professionals to prove that they have been physically active. The main intention was to gain a more personalized treatment:

" It would be great if the physical activity reports could be seen by the healthcare professionals as it could enable more personalized health benefits. Now the application has my personal information in terms of height and weight, but instead there could be heartrate and blood pressure. This might enable me to get information that is relevant to me, which could result as better care." (2)

In the focus group, the participant further continued that it would be beneficial if one could show the healthcare professional [through application or through printing the personal data records from the application] that one has been physically active, even if there were some ongoing health issues. This was illustrated through an example where the healthcare professional had recommended physical activities to reduce pain in a certain condition, but once the person continued to have some issues, she would have wanted the possibility to share the physical activity data, so that the healthcare professional would be aware of the endeavors:

"It would be beneficial if one could print their own physical activity into paper in order to show it to the healthcare professional. There are certain conditions where physical activity is considered to be beneficial and if I, for example, have pain, I could still show healthcare professional that I have been active and show this in a paper. I have been active for all these years, and I would like to show this to my healthcare professional, so it is not only my description but also a list of physical activities that I have been doing over the time." (2)

Basically, the intention to share physical activity data with the healthcare professional connects to the wish of a more personalized treatment at the appointment and a way the healthcare professional could see a proof that the person has been physically active.

4.3 Tracking small acts of everyday life

The participants considered that the data aggregation and automated measurement of small acts of everyday life would be important for more realistic picture of daily physical activity. In the focus group, the participants mentioned that they used to report their physical activity [in the application] daily when it was clearly labeled as an activity, for example, skiing or gym. However, oftentimes, especially due to Covid19, the participants had limited possibilities to do exercises except for doing them at home or in outdoors, and these physical activities they did were often small acts of everyday life, such as cleaning or other household works. However, in these cases, the participants were often not reporting these more casual physical activities in the application, which could result as a misleading picture of how active the day was in the end:

"One feature I wish to have [in the application] is some form of a summary of daily steps. Like what smart watches collect. You can walk a lot during a day, but you do not often report it to the application, so then the real daily activity and the activity you report are not always in sync." (2)

This was complemented by another participant who actively reported daily activities when they were labeled as activities, but the small acts of everyday life she was often unwilling to report as to her, those were not counted as a "real" physical activity:

"Now I report everything [to the application] that I count as physical activity. However, like I said, household work I do not see as physical activity but part of daily life. This is how I see it but it is maybe not the same for others." (3)

Both of these quotes illustrate the differences between individuals when reporting the daily physical activities. First quote illustrates the potential difference between the reported and real physical activity levels, whereas the latter describes the difference between reporting certain activities and whether the activity is "worth reporting". The idea in tracking the small acts of everyday life automatically is in capturing the real physical activity levels when the physical activity is not actively reported to the application.

5 Discussion and Conclusions

In this study, we analyzed how can a physical activity application, a commonly used digital wellness technology, provide support for physical activity among young elderly. We specifically focused on personalization, and the wishes and needs young elderly have for personalization enabled by a physical activity application. We identified three categories of central wishes and needs young elderly have for physical activity applications to enable a more personalized support: 1) More holistic data collection that combines physical activity data and health-related data, 2) Sharing the physical activity data with healthcare professionals, and 3) Tracking small acts of everyday life.

More holistic data collection that combines physical activity data and health-related data refers to the idea of forming a more comprehensive picture of the user's health situation. This connects to the concept of holistic data collection, which Cena et al. (2018) address to illustrate a more holistic representation of the user that form the basis for creating more personalized services. Digital technologies are capable in aggregating different types of data that can be used for personalization (Korhonen et al., 2020), and as our findings illustrate, young elderly have distinct wishes and needs to consider in terms of more holistic data collection.
Sharing the physical activity data with healthcare professionals refers to the idea of sharing the data that is collected with digital wellness technology to gain more personalized services. This connects again with the findings of Cena et al. (2018) as well as Monteiro-Guerra et al. (2020), who found that making the data the user prefers to share exchangeable with other applications is warranted in order to receive more personalized services. In this study, we found that the data sharing was discussed at the level of sharing physical hard copies (e.g., records on paper) of the data, but also at the level of accessibility and making the physical activity data shareable for the healthcare professionals.

Tracking small acts of everyday life refers to the idea of automatically aggregating the small acts of everyday life that are often not manually reported by the users, but when accumulated can generate a big difference in the daily physical activity levels. The users expressed that they often had little interest in manually reporting some casual daily activities, such as household works or short walks, which often lead to them not reporting these activities at all, resulting in a misleading overall physical

activity amount. In other words, the real level of the overall physical activity of the participant is not visible, for example, for the healthcare professional when evaluating the physical activity levels. Therefore, easy-to-use or automated measurements, like smartwatches and many tracking applications today have, are an important feature to consider. It would aid in evaluating the physical activity levels and in planning personalized interventions based on the physical activity level.

Overall, digital wellness technologies can be used to support different aspects of wellness (Kari et al., 2021). Today, different digital technologies are increasingly aggregating data from different aspects of our lives (Harjumaa et al., 2016), and in the field of health-related data-driven personalization, there is evidence that the availability of data can make the health services more personalized for the individual user in a person-centered manner (Korhonen et al., 2020). Scholars have proposed that digital technologies can provide a promising support for the user but involving the healthcare professional in reviewing the data from the digital technologies periodically together with the user can enable a more personalized support (Tong et al., 2021). Connected to this support, interestingly, in our study, the participants stated that they were not that interested in personalized recommendations or personalized goal setting related to improvement. Rather they described that their interests were more in maintaining the current levels of physical activity. In other words, the participants were more eager to have personalized services that can help them in evaluating and maintaining their current condition than personalized services that target for improvement. However, here we should acknowledge that all the participants in our study stated to be exercising regularly, and it might be a different case among less active people. It could also be that the mentioned preference of maintaining the current condition over improving it, is perhaps natural among the young elderly target group, considering their age. Be as it may, from personalization perspective, we suggest that it would be important that the physical activity applications would correctly estimate the user's level of physical activity and condition to provide suitable instructions for the user. Considering that the majority of older people are insufficiently physically active, instructions that would just aim to maintain the current level might not be optimal for the user in terms of health and wellness. Nevertheless, by combining both health and wellness aspects, the physical activity application could provide a more realistic picture of the user's current condition, both to themselves and to the healthcare professionals.

To summarize, the findings of this study concerning 1) More holistic data collection that combines physical activity data and health-related data, 2) Sharing the physical activity data with healthcare professionals, and 3) Tracking small acts of everyday life, complement the prior personalization literature that have investigated the support digital technology can provide for personalization (e.g., Lee et al., 2015; Korhonen & Isomursu., 2017; Cena et al., 2018; Korhonen et al., 2020) by providing a viewpoint of young elderly and their wishes and needs for personalization. We hope our findings can inspire further personalization research, and, from a practical point of view, can be used in the design of personalized services for young elderly.

Like most research, also this study has some limitations to be acknowledged. First, as the study was conducted in Finland, the findings might not account for cultural differences in other countries, which can be considered as a limitation to the generalizability of the results. Second, the study was conducted during the time of Covid19 pandemic, and the worsening of the Covid19 situation led into a situation where it was not safe and possible to collect more empirical data from other groups of young elderly. Hence, we could only conduct one focus group. However, even though the results of this study are limited to a single focus group, we believe that as the young elderly in the focus group were highly familiar with the physical activity application and the research program, they were capable to represent a viewpoint that represents that of the young elderly in general.

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HOLISTIC INTEROPERABILITY FROM A DIGITAL HEALTH INNOVATOR'S PERSPECTIVE: AN INTERVIEW STUDY

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Abstract Current discussions on ensuring inter-organizational care and inter-sectoral collaboration in digital health increasingly prioritize interoperability as a target property. Previous conceptualization either prioritize a technological scope or focus on socio-technical interoperability between organizations. In doing so, the potential to draw on a holistic understanding to support innovators to increase the diffusion of digital health innovations (DHI) into healthcare practice remains untapped to date. This work addresses this gap. An expert study with 29 participants was conducted to explore whether and how the Refined eHealth European Interoperability Framework (ReEIF) can be used to manage DHI processes. The interviews provide insights regarding relevant interoperability aspects from an innovator perspective and opportunities to address these within DHI processes. On this basis, we propose a Digital Health Innovation Interoperability Framework (DHIIF), which is intended to help practitioners achieve more interoperability while improving the diffusion probability of their DHI.

Keywords: digtial health, innovation, interoperability, interview study, framework.

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1 Introduction

Successful diffusion of Digital Health Innovations (DHI) into practice remains a tough challenge. Unfortunately, DHI projects still have a high failure rate, especially when a DHI project's ambition reaches a high-level (Cresswell and Sheikh, 2013; Mair et al., 2012; Standing et al., 2018). Research on Health Information Systems (HIS) already investigated the realm of reasons for failure and generally conceptualized what DH adoption requires. But practice-oriented research lacks in supporting DH innovators in ensuring the later integration of a DHI artifact into health systems and their HIS landscapes. The challenge becomes even more difficult when DHI's complexity and/or novelty increases due to inter-organizational care scenarios, application of new technologies, or new paradigms of healthcare delivery (e.g., value-based healthcare).

For this background, we defined our overall research goal as the derivation of a management framework for DHI processes to promote interoperability. We were thereby guided by three principles: 1. Interoperability is a key property of DHI and crucial for diffusion success; 2. Interoperability is a socio-technical property and requires a holistic conceptualization; 3. Ensuring interoperability is a high-priority goal of DHI processes and requires active management.

We selected the Refined eHealth European Interoperability Framework (ReEIF) (eHealth Network, 2015) as a starting point for our investigation. It suits the stated principles and provides a European consented structurization of interoperability in DH. But its applicability to the context of DHI dissemination is somewhat vague, as it originally focuses on interoperability between organizations. Therefore, we question: How shall the ReEIF be adapted to suit the perspective of DH innovators and support them in DHI processes?

2 Foundations

2.1 Conceptualization of socio-technical interoperability

Interoperability is basically defined as the ability of two or more applications or information systems to effectively and efficiently perform tasks together (HIMSS, 2020; HL7 International, 2021; Zeinali et al., 2016). Technical properties, e.g.,

semantics and syntax, are at the focal point of discussion to ensure communication scenarios between technical systems. National and international committees (e.g., HL7 and IHE) strive to increase standardization and reduce inconsistencies in information flows.

Following the socio-technical understanding of HIS research, interoperability is understood in a broader sense as a construct of technical and organizational dimensions (da Silva Serapião Leal et al., 2019; Kuziemsky and Weber-Jahnke, 2009). Considering the multitude of non-technical aspects that determine a DHI's adoption (Hobeck et al., 2021; Kowatsch et al., 2019), the socio-technical interpretation gains relevance. This is underpinned by a recent article postulating the value of interoperability and ensuring mechanisms in the era of digital innovations (Hodapp and Hanelt, 2022). Thus, we initially conceptualized interoperability as the ability of a DHI and the status quo of a target environment to perform commonly. Thereby, the target environment in which a DHI will be integrated defines four general perspectives:

- Technical Systems collaborating directly or indirectly with a DHI
- People using a DHI or being affected by it (professionals and patients)
- Organizations that manage a DHI's operation as part of a HIS landscape
- Regulations that define duties and limits of a DHI usage

2.2 Refined eHealth European Interoperability Framework (ReEIF)

In 2015, the European Commission's Working Group "eHealth Network" published the ReEIF (eHealth Network, 2015). This framework is intended to support activities in the context of interoperability and standardization challenges. It provides a consented language and supports communication and decision-making processes. It distinguishes technical (Information, Application, IT-Infrastructure) and non-technical levels of interoperability (Legal and Regulatory, Policy, Care Process). Despite some vagueness for the context of integrating a DHI as an artifact into healthcare practice, we chose the ReEIF as initial delineation aid as its intention suits the background of DHI towards inter-organizational healthcare delivery or inter-sectoral collaborations.

From a top-down perspective, the ReEIF is already part of international recommendations. The WHO endorses its member states its adoption within their eHealth strategies to support all involved stakeholders from innovation to implementation (Peterson et al., 2016). The eStandard initiative built on the ReEIF and provided the "Interoperability guideline for eHealth deployment projects" as well as a "Roadmap for a sustainable and collaborative standard development" (eStandards, 2017a, 2017b). The research community also applied the ReEIF in selected contributions, e.g., to derive a framework for the digital transformation of the Greece health system (Kouroubali and Katehakis, 2019) or to propose a reference architecture for future digital ecosystems for primary care (d'Hollosy et al., 2018). In a prior literature study (Scheplitz, 2022), we assigned diffusion-critical aspects to the ReEIF levels and derived detailed descriptions of each level from an innovator's perspective.

2.3 Prior research on diffusion and adoption of DHI

Previous findings from HIS Research and related disciplines demonstrate the extent and complexity of what it takes to ensure the success of DHI. Multiple articles provide comprehensive lists of barriers and facilitators of planning and integrating DHI (Kowatsch et al., 2019; Schreiweis et al., 2019). With a practice-oriented motivation, Hobeck et al. provide a questionnaire based on selected diffusion critical barriers allowing innovators to self-assess a DHI process and align their findings with the ReEIF (Hobeck et al., 2021).

Other scientists faced insufficient DHI diffusion success issues from a top-down perspective. Our work is mainly influenced by two of them. First, in their Clinical Adoption Framework (CAF), Lau et al. provide a holistic, socio-technical evaluation framework for eHealth evaluation (Lau and Price, 2017). Van Mens et al. applied CAF for patient access to EHRs and enhanced it by 43 CAF categories, making it more tangible for other DH evaluation objects (van Mens et al., 2020). But in the end, CAF is primarily suiting rather DHI evaluation than DHI process management. Second, the Nonadoption, Abandonment, Scale-up, Spread, and Sustainability (NASSS) framework defines pertinent, conceptual domains and highlights their interplay within a wider (institutional and societal) context determining sustainable DH adaptation over time (Greenhalgh et al., 2017). This framework is focused on DHI's path from the integration phase to its post-market usage and evolution.

All in all, several contributions discuss the adoption of the ReEIF for practice or consolidate relevant aspects of DH diffusion. They differ in detail but confirm each other in their socio-technical realm. Even though these articles promote awareness for better requirements engineering, the guidance for innovators on DHI process management is limited.

3 Method

A qualitative research approach was chosen to meet the research goal via an interview-based expert study. Experts from research and practice were acquired to discuss in 1-on-1 online interviews aspects of socio-technical interoperability, its criticality, and how innovators can ensure it.

3.1 Study Design

Interview studies have been a valuable qualitative research approach for Information Systems Research for decades (Myers and Newman, 2007; Schultze and Avital, 2011). For this purpose, a semi-formal interview guide was derived. It consists of open and closed questions and is structured in 4 thematic blocks.[1].

- Basic understanding interoperability; Ad hoc evaluation of ReEIF
- Previous DHI experiences; Transition to the study's generic objective in the third block; Description of one recent DHI project
- Change to a prospective, generic perspective; Topics and activities particularly critical to a DHI's diffusion success regarding ReEIF; Innovator's influence on ensuring interoperability DHI processes
- Characterization of participants (background, experience, expertise)

3.2 Data Sample

The participants were mainly recruited via email using German digital health expert networks from research and practice. Further experts were motivated to participate via the snowball principle. In total, 29 experts participated in the 1-on-1 interviews between September and November 2021. In terms of experience, professional

[1] The complete interview guideline can be found in Appendix - https://tud.link/7ua4

background, and core expertise, the participant set is heterogeneous and covers the range of perspectives sought (see Appendix).

3.3 Details of Analysis

All recordings were independently analyzed by two researchers and one research assistant. Responses to closed-ended questions were documented directly for quantifying analyses. Responses to open-ended questions were converted to summarizing paraphrases. After a complete run through the material, all results were consolidated, statements with the same intent were subsumed, and conflicting interpretations were discussed in group sessions by the analysts. Conflicts were resolved into adequate paraphrases under re-screening of recording sequences. The final set of paraphrases was interpreted according to the research question. All analysis activities were oriented towards the recommendations of summarizing, qualitative content analysis (Mayring, 2014).

4 Findings

Our ambitious research goal lead us to a sophisticating extent of paraphrased statements. A selection of those statements is consolidated in the following.[2]

4.1 Critique on ReEIF from an innovator's perspective

Participants were invited to assess the ReEIF from an innovator's perspective regarding critical aspects for the integration of a DHI into practice. The general feedback was positive. However, with a view to comprehensiveness, some participants perceived the following uncovered topics:

Distinguishment of user-centered and process-centered issues. The view of users and how they use a DHI is a prominent factor but underrepresented if positioned within Care Process level.

Highlighting the interplay of technical interoperability levels. Some participants asked how the required data for the functionality of a DHI is covered

[2] All paraphrases are document incl. interview IDs within Appendix - https://tud.link/7ua4

within ReEIF. Here, they assume that the technical levels of ReEIF (Information, Application, IT-Infrastructure) address this in symbiosis but also doubt if innovators would recognize this interplay easily.

Highlighting the business perspective. The definition of appropriate business models as a solid base for activities on the policy level should be presented more popular, since those efforts should not be underestimated, especially for DHI with revolutionary value propositions.

Considering cultural influences. On a macro-level (e.g., the inertia of medico-legal conditions) and on a micro-level (e.g., managing interdisciplinary collaboration), cultural factors influence ensuring interoperability.

Enhance ReEIF in a way that offers implications on DHI process management since it currently does not provide a processual perspective, especially when perceiving a DHI as a dynamic process.

The participants were asked which ReEIF level requires the most attention. Here, answers often tried to balance efforts and relevance. As most experts stated, all levels are equally relevant in general because unawareness of each level could lead to a failure of a whole DHI project. However, 20 experts mentioned that the care process level requires the most attention and reasoned it by i) the high need for communication and analysis resources and ii) a dominating impact of this level.

4.2 Crucial aspects of interoperability

In further questions, we stepped into detailed discussions about the crucial aspects of interoperability. We strove to identify aspects and their alignment to ReEIF levels. However, some participants stated generic aspects. The majority (n=22) highlighted the need for interdisciplinarity to integrate all relevant stakeholders and competencies required by each level. Even though reaching interdisciplinarity requires efforts in organization and communication, the benefits of internal and external commitment to a DHI process and acceptance of a DHI artifact are worth it. More than half of the participants (n=16) mentioned user-centeredness as a maxim and expressed its positive influence on usability and utility (Care Process) and positive follow-on effects on all interoperability levels by the high commitment

of users and stakeholders. Some participants switched to a processual perspective and suggested an early, systematic, and exhaustive requirements analysis that allows a precise definition of a DHI's vision. Other interviewees argued that this definition step should balance the overall ambitions and conclude with a minimal valuable product that promotes communication and development. A few participants suggested early piloting and field trials as close to healthcare practice as possible fostering advantages on technical and Care Process levels and mentioned further benefits in identifying legal and policy hurdles that might otherwise remain hidden.

At the Legal and Regulatory level, the awareness of medico-legal conditions and the fulfillment of regulatory duties have been highlighted, especially regarding ethical approval, intellectual property, technical and medical liability, certification processes, and the medical evaluation for proof of evidence. For the latter one, the systemic issue of a locked-in cycle was mentioned where a missing evaluation hinders a regulatory approval so that field trials can not be conducted and no real-world data is gathered, which reasons the absent evaluation. At the Policy level, the participants named internal, bi-, or multilateral agreements and contracts as central objects. Some participants highlighted here an economic view and stated appropriate business models with sustainable remuneration models as crucial. At the Care Process level, an in-depth understanding of existing care and accompanying processes of coordination and administration plus intended and unintended effects of a DHI's integration was frequently named and shall be ensured by multiple observations of daily practice with and without a DHI.

Some Participants described aspects of technical interoperability levels (Information, Application, IT-Infrastructure) commonly due to their symbiotic interrelation. These aspects follow the principle of reusing existing solutions, standards, or generic specifications. These participants suggested evaluating the state of practice within the target environment, comparing it with the general state of standardization for the specific use case, and claiming consulting services from appropriate associations (e.g., HL7, IHE). Here, a conflictual gap might occur between standardization knowledge vs. the state of its implementation. Some interviewees named this a reason for present and future proprietary interfaces, when the status quo refers to deprecated systems and innovators are forced to provide compatibility. Thus, breaking through this cycle requires legal acts for the mandatory use of modern standards. Furthermore, interoperability on these three levels could be promoted by

innovators by a sound definition of a minimal valuable product, including specifications of required data exchange scenarios. These definitions support negotiation and communication activities as well as early prototyping and testing. It suits interoperability, especially on the Information level that comprises the definition of domain knowledge, its coding, and the use of standards or initiating standardization.

4.3 Ensuring interoperability within DHI processes

Besides the question of "what" are relevant aspects of interoperability, we also asked for the "how" they should be addressed. We distinguished these questions within our interview guidelines. However, as presented in the previous section, the participants frequently reflected on both commonly. We now consolidate fundamental findings of an innovator's influence on ensuring interoperability and how related tasks fit into typical process models.

4.3.1 Proactive vs. reactive influence

All interviewees agreed that ensuring interoperability is a task that innovators are responsible for, even though systemic issues, e.g., legal acts for mandatory use of IT standards, are related to public institutions or official committees. Innovators always have an influence but the way how they force it differs. There are generally two strategies: I. via a proactive influence on the target environment to change the status quo or II. via a reactive influence by compatibility to the target environment. These strategies should rather be seen as ends of a continuum than a binary differentiation. The participants reflected that there might be tendencies of advantageousness but innovators mostly have to balance these strategies.

We discussed such tendencies in more detail. Our first approach investigated if tendencies are related to different ReEIF levels. Here, the participants mentioned that striving for compatibility (strategy II.) leads DHI activities related to Legal and Regulatory and IT-Infrastructure. On these levels, the innovator's potential to achieve changes within a short period in mostly inflexible structures is marginal. The other levels offer more room for proactive initiatives. For Care Process and Information, the participants argued for balancing the strategies. On the one hand, they articulated the inherent change due to a DHI's integration. On the other hand,

the ability and motivation to change established processes in practice are limited. Especially physicians, caregivers, and IT departments might be overcharged with additional changes and are looking for stability. Regarding the Application level, the participants tend to see the potential of motivating changes proactively and benefiting from newly created interfaces. However, these tendencies may vary due to the specific characteristics of a DHI or its context. The participants reflected thereby a DHI's degree of novelty (innovation as evolution or revolution), the general state of standardization for the particular use case, and the extent of involved stakeholders within the DHI project.

4.3.2 Agility vs. stringency

While discussing the innovator's opportunities in ensuring interoperability, the participants reflected on both agile process models (e.g., SCRUM) and more stringent approaches (e.g., V-Model or waterfall model). Agility and iterative development-test cycles fostering user-centeredness and awareness of interwoven care processes and accompanying processes were seen as a maxim.

Overall, the interviewees favored agile approaches explicitly on Care Process, Information, and Application level. Rather stringency than agility is needed on the Legal & Regulatory, Policy, IT-Infrastructure level. Even though these levels would probably benefit from more agility, innovators mostly have to follow mandatory, formally defined processes, are thereby confronted with sequentially required duties, and face time-intensive negotiations. Consequently, DHI processes forcing socio-technical interoperability need to harmonize agile development approaches with top-down required, sequential processes Some interviewees recommended a top-level sequential DHI process, starting with an exhaustive analysis phase to clearly define a DHI's vision and a minimal valuable product. Agile development and testing cycles shall build on this sound basis and will end up again in stringent phases of final evaluation and certification stages. This slightly trivial combination of stringency and agility varies due to DHI project conditions (e.g., private-funded vs. public-funded, internal vs. inter-organizational consortium) and the characteristics of the DHI artifact (e.g., degree of novelty or closeness of DHI's effects on the patient).

5 Discussion

5.1 Digital Health Innovation Interoperability Framework

We reflected our findings against domain-specific diffusion theory (Greenhalgh et al., 2017; Lau and Price, 2017; van Mens et al., 2020) for an adaption of the ReEIF and propose a Digital Health Innovation Interoperability Framework (DHIIF). The DHIIF primarily supports managing interoperability from an innovator's perspective with the overall aim to achieve interoperability holistically and improve the diffusion probability of a single DHI. The DHIIF's center presents seven interoperability levels as enrichment of the six ReEIF levels that describe the relevant topics within DHI processes (Figure 3). Looking through a technical lens, we underline the symbiotic interrelation of Information, Application, and IT-Infrastructure level to fulfill requirements of data exchange that become even more relevant in the light of rising data-centered DHI and AI applications. We further introduce the distinguishment of interoperability from a user-centered and a process-centered perspective. Even though they are interrelated and commonly determine a DHI's utility and usability, innovators should concentrate on both levels separately. Our findings confirm and specify prior results from a literature study (Scheplitz, 2022) that started the adoption of ReEIF for innovators. We further align with adoption theory highlighted in NASSS (Greenhalgh et al., 2017), which describes the influence of the wider system of a DHI project (e.g., its organizational background, conditions of the specific target environment, cultural influences) and longitudinal dynamics on the "how" innovators shall promote interoperability on each level.

Interoperability is a property that targets two or more systems as a unit, not as single parts. Therefore, it depends on the constitution of both the DHI (as an artifact) and the target environment. Strategies to ensure interoperability may differ due to specific conditions but also to characteristics of each interoperability level. We confirmed prior indications (Scheplitz, 2022) about three general principles of dominance in interoperability and related strategies (Figure 4). We derived indications of which strategies should be pursued on each interoperability level of DHIIF. However, we argue that these principles and strategies should not be understood as discrete categories. Instead, they unfold a continuum that allows innovators to define their strategies and activities for a specific DHI process.

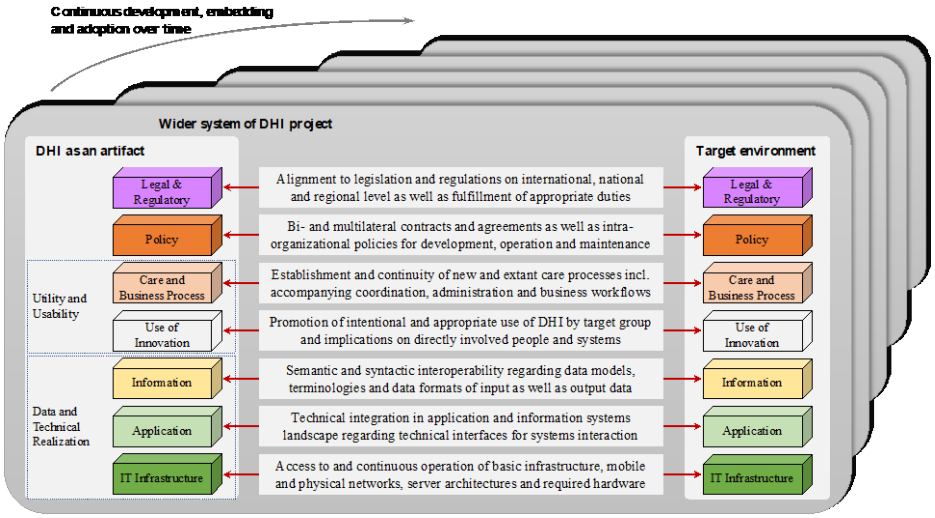


Figure 3: Digital Health Innovation Interoperability Framework

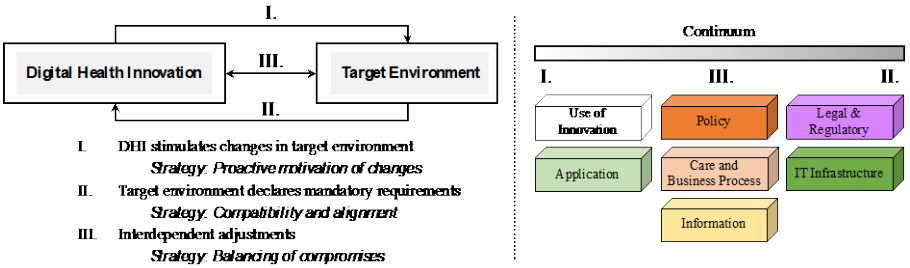


Figure 4: Dominance in Interoperability and indications on ensuring strategies

5.2 Limitations

The results of this study should be evaluated considering a few limitations. A first limitation was indicated by some participants. They described difficulties in making general assessments and motivated differentiation due to the specific DHI context. In this regard, interviewees described three interdependent sensitivity dimensions: 1. the DHI as an artifact including its value proposition, technological approach, and its degree of novelty on each ReEIF level; 2. the wider DHI project context comprising the specific target environment (status quo of technological, organizational, and legal conditions) as well as organizational project background

(e.g., the innovator's status, the structure of consortia or funding conditions); 3. the DHI as a process with a longitudinal view on how a DHI project is conducted to develop and integrate the intended DHI artifact and how resilient this process is on dynamics in the first two dimensions.

Some methodological limitations also influence the validity of our work. As typical for qualitative research approaches, our results are limited in objectivity. We tackled this issue by including a multitude of professional backgrounds and expertise. However, with 29 participants we only conducted a mid-scale study. Furthermore, our results are subject to a national bias, as we almost exclusively interviewed German experts. The amount of internationally operating experts, as well as the rigid orientation of this study along with a European consented framework, strengthen the generalizability of this contribution.

6 Conclusion

With this expert study, we stepped towards more guidance on DHI process management strictly focused on socio-technical interoperability. We gathered knowledge from domain-specific diffusion theory, a prominent interoperability framework, and experienced practitioners to propose a Digital Health Innovation Interoperability Framework that provides structurization and processual implications for ensuring interoperability and increasing diffusion probability.

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WHO ARE THE SHOWROOMERS? SOCIO-DEMOGRAPHIC FACTORS BEHIND THE SHOWROOMING BEHAVIOR ON MOBILE DEVICES

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Abstract This quantitative study focuses on socio-demographic variables and their associations with different forms of showrooming behavior. The purpose of this study is to find which consumer groups based on age, gender, and income level are demographically the most probable showroomers, and how much each of these variables explain showrooming. The data used is a structured online survey from 1,028 Finnish omnichannel consumers aged between 18 and 75 years. We compare the means of demographic groups' shares on different aspects of showrooming, and then use partial least squares structural equation modeling with confirmatory factor analysis to see how much each of the variables explain showrooming. The findings show that showrooming behavior is explained most by age, and that the most probable showroomers are younger consumers, higher income consumers and female consumers. The findings also show that finding information and better prices for the products are the most typical forms of showrooming.

Keywords: showrooming, omnichannel, consumer behavior, mobile shopping, socio-demographics.

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1 Introduction

In today's omnichannel shopping environment, where the seamless usage of all the networked channels is possible (Rigby, 2011; Verhoef et al., 2015; Srinivasan et al., 2016), using mobile devices for shopping has become popular among many consumer groups. With the emergence of these mobile channels, cross-channel behavior has been increasing (Xu et al. 2014; Srinivasan et al. 2016). This means, for example, the use of one channel for information search and another channel for purchasing the product. Showrooming, i.e. the visiting of offline stores before purchasing online, and/or using the mobile channel while visiting offline stores, is one form of cross-channel behavior. It can thus be considered as a part of omnichannel consumer behavior, where consumers integrate the use of various channels of consumption (Rigby 2011; Verhoef et al., 2015). Although different forms of cross-channel behavior have been studied during the past decades, including, for example, webrooming (Kleinlercher et al., 2020), showrooming has not gained much attention from earlier studies. For example, Burns et al. (2019) call for future research on how demographic factors affect the probability to engage in showrooming behavior.

Thus, in this study, we aim to contribute to this call for further research with an aim to describe and compare different demographic consumer groups' probabilities in engaging in showrooming behavior. We also inspect the prevalence of different forms of showrooming behavior, thus providing a more nuanced insight on different consumer groups' different behaviors. In the pursuit for this aim, we use quantitative survey data from Finnish consumers collected in 2021. The consumers are reviewed based on their age, gender and income. Our contribution to the omnichannel literature increases the understanding of the associations of demographic factors with showrooming behavior and its different forms. Additionally, the results will help business management to notice the preferences and tendencies of different consumer groups in showrooming behavior.

In the second section, we first introduce the key concepts and theories related to this study. In the third section of our paper, we introduce our research data and methods. Next, in the fourth section, we test our hypothesis and analyze the results of this. Finally, we conclude with the fifth section by providing conclusions and further research suggestions having emerged from our study.

2 Showrooming in an Omnichannel Context

2.1 The Concept of Showrooming

Showrooming means "a practice whereby consumers visit a brick-and-mortar retail store to (1) evaluate products/services first-hand and (2) use mobile technology while in-store to compare products for potential purchase via any number of channels" (Rapp et al., 2015). In other words, in showrooming, a consumer gathers information offline but purchases the product online, with a physical store serving as a showroom for online products (Mehra et al., 2013; Brynjolfsson et al., 2013). According to statistics, 57 % of respondents living in the USA and the UK have engaged in showrooming (JRNI, 2019), and 21% of Finnish people, 50% of Swedish people and 43 % of Norwegian people showroomed during the year 2018 (Statista, 2019).

The prior research on showrooming has concentrated mainly on asking *why* consumers are showrooming; what are the drivers for engaging in it (Rapp et al., 2015; Daunt & Harris, 2017; Gensler et al., 2017). Commonly researched customer-led drivers for showrooming include, for example, perceived risk, uncertainty, and consumer involvement (Sahu et al., 2021; Balakrishnan et al., 2014). The results, thereby, suggest that the drivers behind showrooming are more complex than just the desire for lower prices in online stores (Gensler et al., 2017). In addition to these drivers, the literature on showrooming has also emphasized the challenges that offline retailers face due to this phenomenon (Fassnacht et al., 2019). According to Rapp et al. (2015), showrooming leads to offline retailers facing *"severe consequences"*, since the shoppers who are going cross-channel are often noted being irrespective of the change of retailer (Grewal et al., 2016). In addition to the potential sales losses, showrooming has also been shown to negatively influence salesperson self-efficacy and performance (Rapp et al., 2015). Therefore, it becomes important to know *who* the most probable showroomers are demographically.

2.2 Demographic Factors Affecting Showrooming Behavior: Age, Gender, and Income

Age. The prior research on age and showrooming has considered age mainly as a control variable. Dahana et al. (2018) found that showrooming frequency was affected negatively by age. Consequently, they found that younger people engaged in showrooming more often than older people. However, their hypothesis of age affecting showrooming probability was not supported. Also, when studying cross-channel free-riding in general, Heitz-Spahn (2013) found that age did not affect the likelihood in these phenomena. However, consistent with Dahana et al.'s (2018) showrooming frequency results, Donnelly and Scaff (2013) found that young adults engage in showrooming more than any other age group. Young showroomers are also suggested to be more driven by mobile and to purchase more via mobile than older showroomers (Schneider & Zielke, 2020). The association of age and the utilization of mobile technologies can also be affected by potential generational differences, which divide consumers into those who have grown up with such technologies and those who have not (Prensky, 2001a; Prensky, 2001b; Fischer et al., 2017). Gilleard et al. (2015) and Madden (2010) have used 50 years' age as a threshold in comparing the use of mobile technologies of younger and older people. Based on the above, we hypothesize:

H1: The older the consumer, the less there is showrooming behavior.

Gender. The effect of gender on showrooming has not been studied extensively. Dahana et al. (2018) did not find gender having a statistically significant effect on showrooming. With the wider omnichannel perspective, no statistically significant relationship between gender and cross-channel free-riding (Heitz-Spahn, 2013) nor gender and multi-channel shopping (Jo et al., 2020) has been found. In spite of behavior, when surveying the attitudes towards showrooming, Burns et al. (2019) found that men regarded showrooming as more ethical than did women. Consistently, Schneider and Zielke (2020) found that women showroomers are more loyal than men showroomers, and stick more with one retailer when switching from an offline to an online channel. However, in omnichannel fashion shopping women were found to belong more often to the category of omnichannel shopping enthusiasts and men to the category of omnichannel reluctants (Mosquera et al., 2019). Thus, we hypothesize that:

H2: Women showroom more than men.

Income. Similarly with showrooming and age, investigating showrooming and income has generated both statistically significant and not significant results. In the US study by Gallup (2013), 40% of the respondents with lower incomes reported having showroomed at least once, while the percentage climbed to 53% for those with higher incomes. This would suggest that consumers with higher incomes showroom more than those with lower incomes. Similarly, Schneider and Zielke (2020) found that respondents with lower incomes engaged less in showrooming behavior and, when doing so, they preferred online purchasing with stationary devices over mobile purchasing. Lower income adults are also generally suggested to be less likely to utilize internet technologies (Kutner et al., 2006; Schmeida & McNeal, 2007). On the other hand, Jo et al. (2020) found no statistically significant relationship with multichannel shopping and annual income. The contradictory results on whether income has a positive or statistically not significant effect make this hypothesis worth testing. Accordingly, we hypothesize that:

H3: The higher the income, the more consumers showroom.

3 Methodology

3.1 Sample and Data Collection

Using a structured online survey, we collected data from 1,028 Finnish omnichannel consumers aged between 18 and 75 years. The respondents were selected from a large panel with random sampling. The criteria for selecting the respondents were that they had visited both the online and brick-and-mortar store of the same retailer. The response rate of the invited panelists was 36%. Non-response bias was assessed by comparing the sample to the gender and age distributions of the Finnish adult population. The sample was found representative of the adult population in Finland with respect to gender and age, and the distribution of the other socio-demographic variables was in line with the demographics of the Finnish population. Thus, it can be considered as representative (OSF, 2021a; OSF, 2021b).

3.2 Measurements and Data Analysis

The respondents of the survey rated three statements measuring showrooming behavior with a 7-point standard Likert scale (ranging from 1=strongly disagree to 7=strongly agree). Respondent were also allowed to not give a rating or leave the questions about their background information unanswered. The statements were: "I often use mobile devices to find more information about products in the store", "I use mobile devices to find better prices for products online", and "I use mobile devices to look for information about products while still in the store". We adopted this established scale from Li et al. (2018), which is consistent with the definition of showrooming by Rapp et al. (2015). The scale was made to fit in the context of this research. Age and annual personal taxable income were measured as ordinal variables with six age and income groups, whereas gender was measures as a binomial variable. These were all used as predictors for showrooming behavior.

Next, we first use Welch's analysis of variance (ANOVA) and independent samples t-tests to examine the differences in the mean ratings of the aforementioned three statements between men and women and across the six age and income groups. If statistically significant differences were found in Welch's ANOVA, the pairwise differences between the age or income groups were examined in more detail by using the Games-Howell post-hoc tests. After that, we use partial least squares structural equation modeling (PLS-SEM) conducted with the SmartPLS 3.2.7 software (Ringle et al., 2015) to examine how these socio-demographic variables together explain showroom behavior.

4 Results

4.1 Mean Comparisons

Generally, the respondents moderately agreed with the statements "I often use mobile devices to find more information about products in the store" (mean 5.00), and "I use mobile devices to find better prices for products online" (mean 4.93). However, the respondents were rather indifferent with the statement "I use mobile devices to look for information about products while still in the store" (mean 4.15). We report the results of the mean comparisons by age groups, gender, and income groups below.

Age. In terms of age, the results of Welch's ANOVA (Table 1) indicated that the respondents had statistically significant differences across age groups in the use of mobile devices to find more information about products in the store (F(5, 332.905)=19.600***), in the use of mobile devices to find better prices for products online (F(5, 333.505)=20.678***), and in the use mobile devices to look for information about products while still in the store (F(5, 336.378)=39.549***). However, the post-hoc tests indicated that these differences mainly existed only between the respondents aged under 50 years and 50 years or over, with the former group agreeing more and the latter group agreeing less with the statements. Thus, in our further analyses in Section 4.2, we focus only on the differences between these two age groups. This is also consistent with prior literature, in which the age threshold of 50 years has been used, for example, when studying the differences in the use of mobile technologies between younger and older people (Gilleard et al., 2015; Madden, 2010).

Table 1: Age and showrooming behavior

	Age	**N**	**Mean**	**SD**
I often use mobile devices to find more information about products in the store. F(5, 332.905)=19.600***	18–29 y.	191	5.70	1.49
	30–39 y.	213	5.42	1.45
	40–49 y.	194	5.28	1.58
	50–59 y.	196	4.36	2.04
	60–69 y.	179	4.40	2.11
	≥ 70 y.	53	4.15	2.09
I use mobile devices to find better prices for products online. F(5, 333.505)=20.678***	18–29 y.	191	5.66	1.40
	30–39 y.	212	5.34	1.49
	40–49 y.	194	5.22	1.62
	50–59 y.	198	4.38	2.09
	60–69 y.	179	4.25	2.16
	≥ 70 y.	53	3.98	2.05
I use mobile devices to look for information about products while still in the store. F(5, 336.378)=39.549***	18–29 y.	188	5.11	1.65
	30–39 y.	212	4.88	1.75
	40–49 y.	193	4.40	1.77
	50–59 y.	197	3.46	1.97
	60–69 y.	178	3.04	1.92
	≥ 70 y.	53	3.13	1.97

*Notes: ns=non-significant, *=p<0.05, **=p<0.01, ***=p<0.001*

Gender. In terms of gender, the results of Welch's t-tests (Table 2) indicated that the respondents had statistically significant differences between men and women in the use of mobile devices to find more information about products in the store (t(1,015.119)=4.428***) and in the use of mobile devices to find better prices for products online (t(1,017.444)=3.142**) but not in the use mobile devices to look for information about products while still in the store (t(1,014.929)=1.461ns). In the case of using mobile devices to find more information about products in the store and using mobile devices to find better prices for products online, women agreed more with the statements than men.

Table 2: Gender and showrooming behavior

	Gender	N	Mean	SD
I often use mobile devices to find more information about products in the store. t(1,015.119)=4.428***	Male	496	4.74	1.84
	Female	526	5.24	1.82
I use mobile devices to find better prices for products online. t(1,017.444)=3.142**	Male	496	4.74	1.86
	Female	527	5.11	1.86
I use mobile devices to look for information about products while still in the store. t(1,014.929)=1.461ns	Male	497	4.05	1.94
	Female	520	4.24	2.04

*Notes: ns=non-significant, *=p<0.05, **=p<0.01, ***=p<0.001*

Table 3: Income and showrooming behavior

	Income	N	Mean	SD
I often use mobile devices to find more information about products in the store. F(5, 358.955)=1.620ns	< 10 k€	87	4.84	1.99
	10 k€ – < 20 k€	218	4.77	1.97
	20 k€ – < 30 k€	180	5.17	1.74
	30 k€ – < 40 k€	169	5.18	1.74
	40k€ – < 50 k€	130	5.18	1.79
	≥ 50 k€	107	5.14	1.69
I use mobile devices to find better prices for products online. F(5, 359.338)=1.448ns	< 10 k€	87	4.62	2.00
	10 k€ – < 20 k€	218	4.76	1.95
	20 k€ – < 30 k€	180	5.09	1.87
	30 k€– < 40 k€	168	5.01	1.84
	40 k€ – < 50 k€	130	5.03	1.77

	≥ 50 k€	107	5.15	1.74
I use mobile devices to look for information about products while still in the store. F(5, 352.867)=2.491*	< 10 k	84	4.14	2.08
	10 k€ – < 20 k€	218	3.81	2.03
	20 k€ – < 30 k€	180	4.16	1.90
	30 k€– < 40 k€	167	4.35	2.01
	40 k€ – < 50 k€	129	4.35	2.05
	≥ 50 k€	106	4.50	1.85

*Notes: ns=non-significant, *=p<0.05, **=p<0.01, ***=p<0.001*

Income. In terms of income, the results of Welch's ANOVA (Table 3) indicated that the respondents had statistically significant differences across income groups only in the use mobile devices to look for information about products while still in the store (F(5, 352.867)=2.491*) but not in the use of mobile devices to find more information about products in the store (F(5, 358.955)=1.620^{ns}) or in the use of mobile devices to find better prices for products online (F(5, 359.338)=1.448^{ns}). In the case of using mobile devices to look for information about products while still in the store, the differences seemed to exist mainly between the respondents with an income of under 30,000 € and 30,000 € or over, with the former group agreeing less and the latter group agreeing more with the statement. Thus, in our further analyses in Section 4.2, we focus only on the differences between these two income groups. This is also consistent with the average Finnish annual personal taxable income, which is about 30,000 € (OSF, 2018), as well as with the prior study by Jensen et al. (2010), which investigated lower income adults' utilization of internet technologies.

4.2 Results

Our study was exploratory in a broad sense, as it tested the effects of several new relationships, and the variables were not normally distributed. In such cases, factor indeterminacy makes covariance-based Structural Equation Modeling (SEM) unsuitable for prediction purposes, and Partial Least Square Structural Equation Modeling (PLS-SEM) is the recommended testing approach (Hair et al., 2017). Thus, our hypotheses were tested using PLS-SEM. The analyses and reporting the results were done according to the guidelines by Hair et al. (2017). For instance, in the model estimation, we used mode A as the indicator weighting mode of the constructs, path weighting as the weighting scheme, and +1 as the initial weights, while the statistical significance of the model estimates was tested by using bootstrapping with 500 subsamples and individual sign changes. As the threshold

for statistical significance, we used $p < 0.05$. The missing values were replaced by means.

4.2.1 Measurement Model

The data were analyzed using partial least squares confirmatory factor analysis. In general, measures for showrooming behavior (mean=4.69, SD=1.90) showed high internal reliability. The evaluation of the showrooming behavior showed acceptable reliability and validity as the standardized factor loadings were all either equal to or larger than 0.87. Composite reliability (Fornell & Larcker, 1981) was above 0.91, and Cronbach's alpha was 0.86, which were both larger than the recommended cut-off value of 0.70 (Nunnally & Bernstein, 1994). Discriminant validity was achieved by using the Fornell–Larcker (1981) criterion and testing the heterotrait-monotrait (HTMT) ratio. HTMT ratios were below the cut-off value of 0.90 (Hair et al., 2022). To summarize, the evaluation of the reflective construct met the commonly set criteria. The conceptual model accounted for 15% of the variance in showrooming behavior.

4.2.2 Structural Model

As hypothesized (H1), a negative effect of age on showrooming behavior ($\beta = -0.36$; $p < 0.001$) was supported by the data (Table 4). In contrast to the hypothesized positive association between male gender and showrooming, the data supported a positive effect of female gender on showrooming behavior ($\beta = 0.07$; $p < 0.05$), thus rejecting H2. With respect to H3, the data supported a positive effect of income on showrooming behavior ($\beta = .08$; $p < 0.01$).

Table 4: Path Coefficients on Customer Showrooming

DV	IV	Hyp.	β	p-value	R^2
Customer showrooming	Age (*18–49 y.* = 0; ≥ *50 y.* = 1)	H1	-0.36	***	0.15
	Gender (*male* = 0; *female* = 1)	H2	0.07	*	
	Income (< *30 k€* = 0; ≥ *30 k€* = 1)	H3	0.08	**	

*Notes: ns=non-significant, *=p<0.05, **=p<0.01, ***=p<0.001*

5 Discussion and Managerial Implications

This study focused on socio-demographic variables and their associations with different forms of showrooming behavior. In so doing, it offers new information on typical showroomers that has been called for in prior research (Burns et al., 2019). Based on survey data from 1,028 Finnish consumers, we studied the associations of age, gender and income with showrooming behavior (Rapp et al., 2015) by using Welch's ANOVA and t-tests as well as PLS-SEM.

Based on our results, younger, female, and higher income consumers are more eager to showroom. Of these three variables, age had the strongest association with showrooming behavior. The result of younger consumers showrooming more is consistent with the results of Dahana et al. (2018) as well as Donnelly and Scaff (2013) and contradictory with the cross-channel free-riding study of Heitz-Spahn (2013). Our results particularly support Schneider and Zielke's (2020) finding that younger people are the most mobile-driven consumers, because our results suggest that the use of mobile channels for showrooming while still being in the store is especially dependent on age. Older respondents were the only respondent group in the whole research that, on average, reported not to showroom while still being in-store. We think that younger consumers tend to showroom and utilize mobile channel everywhere because they are more familiar with using these channels in consumption and everyday life, as Jo et al. (2020) formulate. People aged 50 years or over, i.e. those who were born before 1970, in turn, have already been middle-aged and formed their habits as a consumer before the widespread presence of smartphones enabling the use of mobile channels in shopping.

When perceiving the association of gender, we found gender to affect showrooming behavior, despite gender's association with showrooming or multichannel shopping being statistically not significant in prior research (Dahana et al., 2018; Heitz-Spahn, 2013; Jo et al., 2020). Our results suggest that women showroom more than men. Although the result is consistent with women being omnichannel fashion shopping enthusiasts more often than men (Mosquera et al., 2019), the finding of women showrooming more is interesting. This is considering the prior findings where, compared to men, women perceived showrooming less ethical (Burns et al., 2019) and were more loyal showroomers (Schneider & Zielke, 2020). Although women showroomed otherwise more in our study, we found that while still in-store, women

did not showroom more than men. This is consistent with prior literature, for instance with Schneider and Zielke's (2020) finding that women are underrepresented in mobile-driven showrooming. Women's showrooming behavior could be explained, for example, by their risk minimizing propensity in online shopping (Liebermann & Stashevsky, 2002). Because of the contradictory results on gender's association and its significancy on showrooming behavior in the omnichannel literature, different showrooming attitudes and styles of genders should be studied more in the future.

When it comes to income, our results of people with higher incomes showrooming more are consistent with prior research reporting similar results (Schneider & Zielke, 2020; Gallup, 2013). Our result of higher incomes' association with showrooming more while still in-store is especially consistent with Schneider and Zielke's (2020) finding on people earning more also using mobile channels more in showrooming. However, income's positive association with showrooming is contradictory with Jo et al. (2020), who found no relationship between multichannel shopping and annual income. The found positive association of income could be explained by people with higher income doing more high-involvement purchases. All in all, the combined effects of the demographic variables suggest that age is the most important antecedent of showrooming behavior, then annual income, and lastly gender. Thus, the most probable showroomers seem to be younger customers with higher income.

Our results provide useful information for retailers on recognizing the most probable showroomer groups. In brick-and-mortar retail stores, the salespersons and their advice provide important help to customers to finalize the purchase in the store, reducing their showrooming behavior (Rapp et al., 2015; Gensler et al., 2017; Fassnacht et al., 2019; Linzmajer et al., 2020). According to our results, the most probable customer groups to showroom are younger customers, higher income customers, and female customers. Thus, targeting the measures, such as quickly available sales advice, especially to these groups could help reducing offline stores' customers' showrooming behavior.

5.1 Limitations and Future Research

This study has certain limitations that leave opportunities for further research. Firstly, the respondents are from Finland, and thus the results cannot be generalized to other countries' contexts. Secondly, the established scale and statements of showrooming behavior (Li et al., 2018) include only mobile channels and do not include online channels. We point out that this can reduce the actual number of showroomers, since our results suggest that showrooming while still being in-store is less common than searching for information or lower prices afterwards, possibly via stationary devices. Thirdly, future research could analyze multiple age and income groups instead of two groups of this study. Finally, the nature of this study was quantitative, and we cannot analyze the motives and attitudes behind the respondents' behavior. Qualitative research is needed to explain these results in detail, especially the contradictive result of gender's effect. Also other combined effects, for example attitudes, skills and other online behavior and consumer behavior, could be researched in the future.

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Appendix 1: Data description of the respondents.

Gender	**N**	**%**
Male	497	48.5
Female	527	51.5
Age	**N**	**%**
18–49 years	595	58.1
50–75 years	429	41.9
Annual personal taxable income (€)	**N**	**%**
Under 20,000 €	304	34.3
20,000–39,999 €	349	39.3
40,000 € or over	234	26.4
Missing	137	–

THE GOOD, THE BAD, AND THE DYNAMIC: CHANGES TO RETAIL BUSINESS MODELS DURING COVID-19

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Abstract Crises, such as the COVID-19 pandemic, challenge the economy and require firms to become resilient to external change. During COVID-19, the retail industry faced double-edged consequences. While brick and mortar business models (BMs) were discontinued, online retail thrived. Extant BM research has investigated several crises; however, it still lacks an explanation of how BM change increases resilience to cope with crises. We analyze the BMs of 45 European retailers and the BM changes implemented during the COVID-19 pandemic and their influence on the retailers' revenue. We identify three types of retailers implementing different strategies to cope with the crises: the »good,« the »bad,« and the »dynamic.« These represent resilient BMs, un-resilient BMs, and BMs becoming resilient enabled by digital technology. We show how BM change creates resilience and performance benefits. For practice, we show how retailers adapted their BM to a crisis leveraging digital technology.

Keywords: business model, resilience, COVID-19, innovation, retail.

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1 Introduction

COVID-19 has had a severe impact on industries like tourism through the imposition of travel restrictions. In contrast, others, such as home entertainment and software, have benefitted immensely from people having to stay at home. One industry that has experienced various reactions to the crisis is retail. Especially, brick-and-mortar retailers have faced various governmental actions restricting their business operations. For example, retail was closed completely, opened with limited opening hours, or with limited customer capacity, excluding infected, untested, and unvaccinated customers. On the contrary, online retailers were thriving.

While a crisis can have detrimental effects on businesses, it also creates opportunities and potential for innovation (Chisholm-Burns, 2010). Innovation in a time of crisis is necessary for a firm's long-term survival and building resilience (Floetgen et al., 2021; Wenzel et al., 2020). One way of improving resilience and gaining a competitive advantage during a crisis is to adapt the business model (BM) (Ucaktürk et al., 2011).

The BM describes how a firm creates and captures value and impacts its performance (Zott & Amit, 2007). BM research provides insights into how a firm can cope with a crisis and sustain its performance. Extant BM research covers crises such as the dot-com bubble and the 2008 global financial crisis and several natural disasters. This research shows how differences in BMs within a focal industry affect financial performance during and after a crisis (Hryckiewicz & Kozłowski, 2017; Ritter & Pedersen, 2020). Additionally, BM change provides a gateway towards creating resilience and even securing a long-term competitive advantage (Ucaktürk et al., 2011; Wenzel et al., 2020).

However, BM research primarily analyzes individual case studies and lacks generalizability (Lambert & Davidson, 2013). Moreover, since the emergence of the BM concept, there have only been three major economic crises, which further limits our knowledge of BM change and its impact in times of crisis. Thus, research lacks an explanation and practical guidance about how BM change can improve a firm's resilience to crisis. Hence, we propose the following research question: *What are BM changes in retail to cope with COVID-19?*

We conduct a qualitative case survey analysis (Larsson, 1993), collecting a sample of 45 large, publicly listed European retailers. Based on publicly available data, we analyze their BM changes implemented during the pandemic and identify twelve BM changes, primarily based on digital technologies. We identify three types of retailers through qualitative comparison of these changes, their pre-COVID-19 BMs, and their financial performance during the pandemic. The three types allow us to derive successful resilience strategies that support trends in retail and thus will probably prove successful even after the pandemic. We contribute to research on BM resilience, BM change, and digital retail. We identify resilient and non-resilient BM patterns that cause firms to either cope well or not so well with the COVID-19 crisis. We also identify BM changes that improve retail firms' coping with the crisis. We show how retailers gain resilience through BM changes and suggest digitalization strategies for future success in digital transformation. For practice, we provide tangible BM changes and practical examples of which BM changes were implemented and proved to improve retailers' resilience and revenue performance successfully.

2 Theoretical background

2.1 Business models during economic crises

Changing BMs in times of crisis is a new line of research based on the continuing importance of BMs (Massa et al., 2017). The two global crises BM literature covers are the 2008 financial crisis and the dot-com crash of the early 2000s. However, during the COVID-19 pandemic, scholars have placed renewed attention on the role of BMs during crises (Breier et al., 2021; Ritter & Pedersen, 2020; Seetharaman, 2020). Crises create tense situations endangering various parts of society. However, they also present opportunities for innovation. For example, the car radio, the supermarket, and even the Monopoly board game were all invented during the great depression (Chisholm-Burns, 2010). More recent examples such as WhatsApp, Airbnb, and Uber were founded during the 2008 financial crisis. The rise of Internet firms and the parallel emergence of BM research (Amit & Zott, 2001) was followed in the early 2000s by the dot-com crash. This resulted in a backlash to the BM concept that saw its viability questioned and condemned firms for focusing solely on their online business and losing sight of their business as a whole (Porter, 2001). However, it also spawned increased research into the BM and its importance (Ritter

& Pedersen, 2020). Roughly a decade later, government deregulation and consequent excessive risk-taking by banks led to a financial crisis that soon took on global economic proportions (Crotty, 2009). Relevant BM literature mainly focused on financial institutions, but it also generated research on BMs in general in times of crisis. The BM influences a firm's performance before, during, and after a crisis (Böttcher, Bootz, et al., 2021; Curi et al., 2015; Hryckiewicz & Kozłowski, 2017; Weking et al., 2019). Along with the focus on financial performance, BM resilience emerged. Research now concentrated on differences in BM resilience (Mora & Akhter, 2012) and the reasons for organizational resilience, such as management awareness (Ritter & Pedersen, 2020) and inter-firm partnerships (Birchall & Ketilson, 2009). On a BM level, customers favored low-cost offerings such as low-cost airlines (Štimac et al., 2012) during a crisis. Ultimately, the financial crisis in 2008 had such a severe impact on the airline BM that it can still be felt today. Consequently, BM innovation during a crisis is a source of resilience that can even produce a competitive advantage after the crisis (Ucaktürk et al., 2011). On the downside, the failure of firms to adapt their BMs during a crisis is one cause of bankruptcy (Beqiri, 2014). To innovate or adapt a BM, firms first need to understand their current BM (Böttcher & Weking, 2020; Chesbrough, 2007). From there, they can either innovate their BM to possibly even thrive during a crisis or decide to retrench parts of it to limit the negative repercussions (Ritter & Pedersen, 2020). For example, Uber's drivers faced low incomes, as transportation in lockdowns is seldomly required. Uber assisted them by adapting the BM from transporting people to transporting medicines and enhancing its food delivery BM (Scheepers & Bogie, 2020). In the hospitality industry, firms primarily rely on financial aid from the government. However, BM changes, such as delivery services or meal pick-ups, help to limit financial losses (Breier et al., 2021).

2.2 Business models in retail

Since the turn of the millennium, the rise of the Internet has ushered in retail's digital age. While, at first, the rise of online business resulted in the dot-com bubble, the digital age manifested itself in the declining importance of brick-and-mortar retail due to the inexorable rise in the importance of e-commerce. Frequently, retailers no longer serve as intermediaries but as multifaceted digital platforms (Sorescu et al., 2011). Due to the rapid pace of digital innovation, retailers now have to constantly adapt their BMs (Böttcher, Rickling, et al., 2021; Frew, 2017; Gavrila & de Lucas

Ancillo, 2021). Multichannel retail, which consists of offline and online channels, has also developed alongside pure e-commerce (Kumar et al., 2019). This concept is currently being developed further into omnichannel retailing. Omnichannel retailing, too, is based on multiple sales channels, for example, brick-and-mortar stores, online stores, and digital applications (Brynjolfsson et al., 2013). However, in omnichannel retail, the different channels are seamlessly integrated and enhance each other rather than existing in parallel (Cao, 2014; Liao & Yang, 2020). The omnichannel BM aims to create a superior digital customer experience (Verhoef et al., 2009). A successful digital retail BM is enhanced by engaging with customers, for example, through social networks or websites, to support their experience even when not shopping (Grewal et al., 2017). In addition, digital BMs allow customer data to be collected, leveraging this data for personalized content or offers tailored to the customer and creating personalized experiences (Baecker et al., 2021; Böttcher, Li, et al., 2021). In summary, the retail industry is amidst a digital transformation. Moreover, being an industry that is significantly exposed to the kind of closures and social constraints caused by COVID-19, primarily offline retailers have faced constraints to their BM that they have had to address to survive the economic crisis.

3 Method

We conduct a case survey to obtain generalizable, cross-sectional insights from qualitative data (Larsson, 1993). We collected our case sample from Crunchbase. Crunchbase is a comprehensive firm database that includes financial ratios and descriptive attributes, as well as descriptions of organizations' value propositions. We have filtered based on three criteria. First, firms need to be assigned to the retail industry. Second, to ensure that the available data on financial performance was reliable, we only included publicly listed firms. Third, firms had to be headquartered in Europe to establish comparability across firms. The initial search resulted in 183 firms. According to our criteria, we excluded firms from this initial sample that were not retailers (n = 65), that did not provide sufficient (n = 23) or comparable financial information (n = 47), and that did not operate in Europe (n = 13). Eventually, our final case sample consisted of 45 firms, whose 2019 and 2020 were then collected from their annual reports.

To analyze the pre-COVID-19 BM, we coded their pre-COVID-19 BM using 19 retail-specific BM patterns by Remane et al. (2017). Following Böhm et al. (2017), we coded each firm according to whether it applied a pattern or not in its BM. For

this coding, we used information collected from their websites and annual, semestrial, and quarterly reports published before March 2020. This resulted in binary vectors for each firm, that defines their pre-COVID-19 BM. To identify BM changes during COVID-19, we used the same sources, adding recent news articles and firm statements. We followed an inductive coding procedure to identify patterns of BM changes through open, axial, and selective coding (Strauss & Corbin, 1998). After coding which retailers implemented BM change, we qualitatively analyzed the pre-COVID 19 BMs, the BM changes, and revenue performance to identify patterns of retailers' actions and performance during the pandemic.

4 Results

4.1 Business model changes

In response to COVID-19, we found 265 individual BM changes, grouped into 12 BM changes presented in the following. On average, firms implemented 5 BM changes during COVID-19. Most common were home delivery (n = 20), click and collect (n = 19), omnichannel and social responsibility (both n = 18). Generally, most firms were found to be accelerating the process of digitalization, and a trend towards *omnichannel* was apparent. Omnichannel refers to the concept of reaching a customer on as many touchpoints as possible. It creates a seamless customer experience, in which the lines between the different channels are blurred. Many of the BM changes contribute to omnichannel retailing. However, due to COVID-19, efforts have been accelerated. For example, ICA Gruppen accelerated their online shop rollout and added such services as click and collect, and they also developed a mobile app.

Online channels have been on the rise since the inception of the Internet and following the creation of pure-play online retailers. The COVID-19 pandemic limited mobility and customers spent more time at home and ordering online. This has forced retailers to adapt or improve their online channels. For instance, Cafom, a home furnishings retailer, created dedicated websites for each of its stores to assist customers in obtaining information about store opening times, what products are available, and what services are provided. Others, such as M.Video, a consumer electronics retailer, added online shops to digital platforms, despite already having their online channels.

Click and collect refers to ordering products online and picking them up at the store in person. Due to COVID-19, click and collect has increased drastically. We observe deviations from the regular in-store collection by enabling pick-up independent of opening hours. For example, Axfood and X5 Retail Group, both grocer retailers, and M.Video offer order collection from locker storage. Similarly, Dunelm and Teknosa offer a drive-through click and collect service.

Home delivery is another example of a service that has been offered before but gained new attention during the pandemic. Retailers added delivery services to their BMs and lowered the usage barriers, such as minimum order value. Furthermore, subscription services, well known from digital services, were introduced to various retail BMs. For example, Carrefour created a weekly food box delivery subscription service. Others, such as Ahold Delhaize, ICA Gruppen, and Matas, a drugstore chain, offer premium customer subscriptions with unlimited free delivery and special promotional offers.

Express delivery fulfills customers' need to receive products immediately rather than wait a few days. In this sense, express delivery fulfills the same need as click and collect, where customers order online and receive products as fast as possible. For example, the X5 Retail Group created an express delivery platform to connect their store network and manage their orders for express delivery options. The express delivery options increase convenience and allow firms to differentiate from competitors.

During COVID-19, retailers increasingly invested in *app development* to offer additional convenience services and engage remotely with their customers. On the one side, firms, such as ICA Gruppen, developed apps for new BMs, such as the delivery of pre-cooked meals from professional cooks whose restaurants were closed. On the other side, they incorporated functions to engage with their customers digitally. For example, M.Video added a video call function to their app to enable customers to call consultants in-store for assistance in online shopping.

New payment services support *new digital services by retailers*. While contactless payment was already well underway, COVID-19 increased the need for contactless or other payment options, such as self-checkouts. Magnit and Ozon have even

developed their payment services enabling cashback on purchases. This aims to retain customers, collect customer data, and encourage repeat purchases.

By introducing *virtual shopping experiences* (VSEs), retailers have implemented new digital formats to present their products to customers. Carrefour and Axfood piloted voice-controlled shopping using intelligent home assistants, such as Google Nest. Magnit offers customers digital tours of their stores, while Dunelm offers one-on-one shopping with sales assistants present in a store using video calls. Hugo Boss, a luxury clothing brand, used TikTok to create challenges and even revealed their newest collection in a live stream on the video platform.

Social responsibility refers to a firm's involvement in supporting local communities. COVID-19 hit small firms particularly hard, as they often do not possess the resources and capabilities to implement digital BMs. Larger retailers have, in many cases, taken the responsibility to support small local firms. For example, Ahold Delhaize and Axfood started buying from local producers who generally sold to restaurants, whose demand plummeted due to restrictions. Online retailers, like Cnova, offered product placements for free and Ozon offered their digital knowledge to support small firms to create a digital presence.

Partnerships played a critical role due to the urgency of implementing these changes. Partnerships with specialists, such as delivery services like Deliveroo or Uber Eats, and even taxis or technology providers fastened the implementation, especially when the retailers did not possess the required capabilities before. For example, Carrefour partnered with a SaaS startup focusing on grocery retail to implement their express delivery service. They also partnered with a live-streaming platform to implement their VSEs. Partnerships also enabled the implementation of the aforementioned express delivery.

Of course, not all retailers implemented the changes mentioned above. Most pure online retailers were able to continue their *business as usual*. Also, following a cost leadership strategy, low-cost retailers continued the BM successfully, as customers favored cheap products. Finally, some retailers had retrenched parts of their business. Retailers in *retrenchment* had to close stores, cut down on staff, and negotiate rent with their landlords to manage expenditures. For example, Hugo Boss and Geox had to postpone future investments in new stores and launch new collections.

4.2 The good, the bad, and the dynamic

Changes in revenue range from an increase of +81.60% (e.g., Farfetch, a luxury fashion retail platform) to a decrease of -63.37% (e.g., Dufry, a duty-free retailer operating in airports, on cruise ships, etc.). The Shapiro-Wilk normality test reveals a normal distribution of the revenue change data ($p > 0.05$). To analyze the differences in revenue change among our case sample, we divide the sample into three subsets, comprising retailers who can continue their business as usual ($n = 11$), retailers who have to retrench their operations ($n = 12$), and all the others, i.e., those who are trying to manage the pandemic by implementing various BM changes ($n = 22$). The »*good*« retailers continued their business-as-usual. Their average revenue increase amounted to +36.92%. Thus, in relation to their peers, they profit from the pandemic. As they do not change their BM, apart from adding some functionality to previously existing online channels, the source of their good financial performance is their pre-COVID-19 BM, usually pure online or low-cost BMs. The »*bad*« retailers had to retrench parts of their BMs. Their average revenue increase amounted to -35.29%. While the retailers in this subsample tried to adapt their BM to cope with the pandemic, primarily focusing on online channels to implement an omnichannel BM, we observe no overall pattern in their responses. However, we do observe two patterns in their pre-COVID-19 BMs. First, high-quality retailers focusing on superior customer experiences in their stores failed to transfer these experiences into an online environment during lockdowns and store closings. Second, franchise retailers who frequently build on customer loyalty lost major revenue. The »*dynamic*« retailers changed their BM to manage the crisis successfully. They show a higher average revenue change (+ 7.66%) and slightly higher median (+ 5.84%) than the overall sample. Regarding their pre-COVID-19 BM, these firms build on customer loyalty and customer relationship management. In contrast to the »*bad*« sample, »*dynamic*« retailers supported their customer engagement through BM changes by leveraging new mobile apps, new payment services, and express delivery. They also build new digital relationships with their customers. Due to their satisfactory financial performance, they could also engage in social activities to engage in social responsibility activities.

5 Discussion

Due to COVID-19, research and practice increasingly discussed how firms could become more resilient to major and minor environmental changes. The BM is shown to be an influencing factor for firm performance (Böttcher, Al Attrach, et al., 2021; Böttcher, Bootz, et al., 2021; Weking et al., 2019). BM changes are a relevant source of innovation and, if implemented by competitors, can create significant changes in the competitive environment of a focal firm (Böttcher, Phi, et al., 2021; Böttcher & Weking, 2020). Thus, the BM can be a source of disruption and increase firms' resilience. Retail has been affected particularly strongly by social restrictions due to COVID-19. Therefore, we analyze the BMs before, and BM changes implemented during COVID-19 of 45 European retailers and compare the revenue performance of these firms.

We identify twelve patterns of BM changes and three types of retailers, the »*good*,« the »*bad*,« and the »*dynamic*,« with different performance outcomes demonstrating different types of resilience. The »*good*« retailers performed exceptionally well during the pandemic, grounding their performance in their pre-COVID-19 BM. The e-commerce and low-cost retailer patterns thrive in the current situation. While their offline competitors were forced to close their stores, e-commerce retailers profited from the fact that people stayed at home and ordered online, which reduced competition from the offline world. On the other hand, the economic crisis led to decreased consumer confidence. Economic uncertainty, reduced income, and the increasing threat of job loss led to increased price sensitivity. Thus, retailers employing the low-cost pattern benefited from the pandemic. Compared to the pre-COVID-19 period, the »*bad*« retailers lose revenue. On the one hand, these are premium retailers offering superior customer experiences in their stores. However, they could not transfer this experience to the online world when stores had to close. Additionally, customers avoided making any expensive investments due to the aforementioned economic uncertainty. On the other hand, we observe that franchise retailers suffer in the crisis. Such franchise stores are often located in highly frequented places, such as malls or city centers. During the COVID-19 lockdowns, malls were closed, and people avoided potentially crowded places. Additionally, the headquarters had no direct influence on franchise stores through the franchise organization. Thus, it was up to the franchisees to respond to the crisis by changing their BM (e.g., offering click and collect), making a unitary response difficult. In

comparison, we observe resilient BMs on the one hand and non-resilient BMs on the other hand. The COVID-19 pandemic, societal lockdowns, and significant economic downturn reveal how resilient a BM is. Such BM resilience is crucial to whether a firm can survive or even thrive in times of crisis. In addition to BM resilience, our results also show another form of resilience. The »*dynamic*« retailers demonstrate the opportunities of BM change in response to the pandemic. Retailers leveraged digital technology, such as mobile apps or new digital payment services. They also built up resilience based on customer relationships. Using mobile apps, VSEs, online channels, etc., these retailers began to engage more with their customers. As the customers' needs shifted in the pandemic, dynamic retailers changed their BM. For example, customers started buying building materials from hardware stores. Using apps and video calls, hardware stores could assist and advise their customers. The implemented changes support the overall trend in retail towards omnichannel BMs (Keiningham et al., 2020; Sorescu et al., 2011). The BM changes we observe during COVID-19 are necessary to their future survival (Bell et al., 2014). Now, as customers have experienced how the integration of online and offline can work, these BMs will become the norm rather than temporary (Breier et al., 2021; Seetharaman, 2020).

5.1 Contributions to research and practice

This paper shows how a BM influences how firms cope with the COVID-19 crisis. We also show how a change to the BM helps firms build resilience. Hence, this paper contributes to research on BMs, especially BM change and BM resilience. First, we show how retailers changed their BM during the COVID-19 pandemic and gained resilience. As the pre-COVID-19 BMs could not be continued during the pandemic, retailers needed to adapt. In this respect, we contribute to the scant research on BMs during economic crises (Ritter & Pedersen, 2020). Second, we contribute to the emerging stream of research on BM resilience (Niemimaa et al., 2019) and performance implications of BMs (Spiegel et al., 2016). We show resilient BMs that outperform others (the »*good*«) and point out BMs that are particularly prone to underperform (the »*bad*«). The BM changes improve and especially digitalize the customer experience to create BM resilience and improve performance, highlighting the importance of the digital transformation in retail. We show how retailers leverage BM change and digital technology to enable them to evolve towards omnichannel BMs by seamlessly integrating online and offline channels (Brynjolfsson et al., 2013;

Hansen & Sia, 2015). Omnichannel BMs and digital customer experience are set to be the new normal, and the COVID-19 pandemic is only accelerating this development.

5.2 Limitations and future research

There are some limitations to this research. First, our analysis is limited to European and publicly listed retailers. While our case sample provides a cross-section of retailers covering different areas from groceries to luxury fashion, it is limited to large firms. Small or medium-sized retailers with limited resources may adapt their BMs differently. Second, we did not account for long-term developments that began before the onset of COVID-19. Third, our research relies on publicly available information reported by the firms and relevant news outlets. Therefore, we may not have captured all the details of the BM changes. Future research can build on our findings to analyze the long-term effects of BM changes implemented during the pandemic. The BM changes leading to superior short-term performance identified in this paper primarily improve the customer experience by creating digital experiences for customers, supporting extant research. Future research can verify whether the BM changes identified to improve the digital customer experience are substantial and whether they also lead to improved business performance in the long term. This could provide further insights into the claims that COVID-19 served as a catalysator for digital transformation, forcing even reluctant firms and industries to engage in digital transformation initiatives.

6 Conclusion

In this paper, we analyze the BMs of 45 European retailers and changes to BMs and performance during the COVID-19 pandemic. We find two types of resilient BMs and two types of non-resilient BMs. In addition, retailers that use digital technologies to affect BM's chance of connecting with their customers in difficult times are coping better than others.

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Combined AI Capabilities for Enhancing Maritime Safety in a Common Information Sharing Environment

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Abstract The complexity of maritime traffic operations indicates an unprecedented necessity for joint introduction and exploitation of artificial intelligence (AI) technologies, that take advantage of the vast amount of vessels' data, offered by disparate surveillance systems to face challenges at sea. This paper reviews the recent Big Data and AI technology implementations for enhancing the maritime safety level in the common information sharing environment (CISE) of the maritime agencies, including vessel behavior and anomaly monitoring, and ship collision risk assessment. Specifically, the trajectory fusion implemented with InSyTo module for soft information fusion and management toolbox, and the Early Notification module for Vessel Collision are presented within EFFECTOR Project. The focus is to elaborate technical architecture features of these modules and combined AI capabilities for achieving the desired interoperability and complementarity between maritime systems, aiming to provide better decision support and proper information to be distributed among CISE maritime safety stakeholders.

Keywords: CISE, maritime safety big data, AI.

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1 Introduction

Nowadays, maritime safety agencies are faced with many challenges varying from the high intensity of maritime traffic, vessel collisions in coastal areas, environmental risks from ships accidents, irregular maritime border-crossing and illicit activities at sea. Maintaining the required strategic and tactical level of maritime safety in a complex environment calls for support of sophisticated and smart ICT technologies, ready to assist in performing the operations of vessel traffic services and national rescue coordination centers (VTS/NRCC). The ever-increasing large amount of vessel data, collected through heterogeneous sensors and information sources demands appropriate structuring for exchanging them among collaborative agencies for undertaking joint operations and safety/security missions at sea and border. Therefore, in this paper we analyse the most important objectives that maritime safety sector strives to:

1. achieving greater maritime situational awareness through institutional networking among relevant agencies for Common Operational Picture at sea,
2. full exploitation of the latest innovative achievements, automated ICT technologies and big data science, capitalizing on versatile applications of AI for maritime purposes, such as anomalies detection and navigation predictions.

The goal of the paper is to present a case study EFFECTOR about maritime safety and two specific solutions conmbined AI features and how these need to be adapted for maritime context. Methological approach of this research reviews CISE as maritime safety EU initiative, the Big Data collected from various maritime sensors and shared among CISE network, with combined AI capabilities for the purpose of efficient response of maritime operative systems. Consequently, the paper unfolds as follows: Chapter 2 elaborates CISE in more details, while Chapter 3 reviews Big Data impacts on development of AI technologies in maritime environments. In Chapter 4 the case study presents EU project EFFECTOR with its specific solutions based on combined AI features for data/information fusion and vessel collision prevention.

2 CISE EU initiative in maritime safety

Considering that maritime safety critically relies on vessel surveillance systems and fast information flows networked via maritime authorities' national competent systems, the need for regional and international cooperation of European stakeholders has led to the establishment of the concept of Common Information Sharing Environment (CISE). The idea of establishing the CISE concept stems from the EUCISE2020, a test-bed project that triggers a creation of a common network for sharing and exchanging relevant maritime data and information between collaborating authorities. This concept was developed and extended through further innovation action projects supported by European Commission (EC) and aimed to improve the current performance in information sharing. That is why CISE was used in EFFECTOR project. Following the latest level of development concept, in Figure 1 we depict general CISE Architecture aligned with the most common data/message flows, actors, and related software/AI components as decision support tools and services. Based on documentation EC COM (2009) 538 and European Maritime Safety Agency (EMSA) Guidelines for CISE [EMSA CISE Architecture document, 2012], whole information sharing/retrieval/ interpretation process is managed via CISE Data & Services Model, compliant with NATO Architectural Framework NAFv3. It is structured in five main object blocks (Paladin *et al.*, 2021): Legacy System (LS) of participating agency, EU/Regional/National CISE Node, CISE Adaptor, CISE Node/Gateway, and CISE Network. In detail, LS is an ICT system/network of a particular authority, integrated with surveillance sensors, which collects, integrates, stores and visualizes maritime Big Data received by their own assets (radars, AIS systems, METOC data, NMSW, UxV) or received by EU Centers (LRIT, AIS/MAREΣ, IMS), which are able to interoperate with other agencies. EU/Regional/National CISE Node provides the integration of one or more national maritime authorities proxied via combined instances of the CISE adaptors for each LS. Most usually, these LS-specific CISE adaptors for data stream sharing are connected to the Command and Control (C2) platform accompanied with Data Fusion and Analytic Services Layer & Decision Support Services Layer/Tools. This structure is mostly supported with Big Data infrastructure and specific AI components, like Machine/Deep Learning Libraries, trajectory prediction and vessel collision risk mitigation. Such combined AI capabilities in high-level operational C2 software provide an intelligent support for decision making based on comprehensive maritime Common Operational Picture. Finally, via CISE Adaptor for data translation and CISE Node/Gateway (a component giving the access to the EU/Regional Node consolidated information in a central database), the CISE Network facilitates the exchange of mentioned information in full compliance with

the CISE message pattern among CISE Member states and EU agencies. Accordingly, the structure of the maritime CISE Data & Service Model defines in its vocabulary CISE Core and Auxiliary Entities concerning agents (person or organization), objects (vessel, operational asset), event (action, anomaly, incident), location, period, risks, documents (metadata), using XSD (XML Schema Definition) or UML (Unified Modelling Language). Being enhanced, the CISE Model introduces tasks, mission, operations, movement, maritime anomalies and sensors (AIS, radar, camera). For instance, the maritime risk type identifies crisis, border crossings, areas, vessels collisions, military and environmental risks (Mihailović *et al.*, 2021a and 2021b).

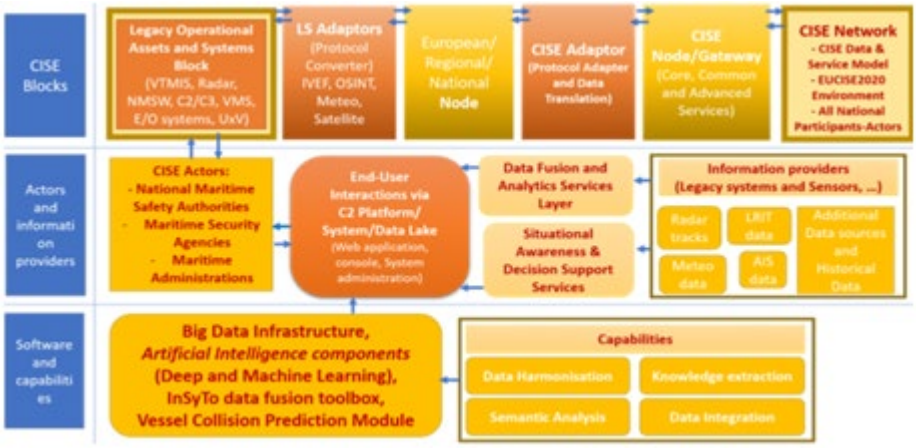


Figure 1: CISE Architecture and Information Flows supported with AI components
Source: authors' adaptation

3 Big data impacts in the development of AI technologies applied in maritime safety

In general, AI technologies, with their cognitive, forecasting and reasoning functions are intensively developed toward providing greater software support to human operators and agencies, increasing the level of automation in the maritime transport sector. The aim is to strengthen the maritime safety domain by utilization of prospective applications able to manage Big Data as: vessel route/paths control and optimization, vessel traffic surveillance, prevention of collision, possible fault/failure detection in ship operations, etc. Primarily, maritime AI applications retrieve the vast amount of data from different data source types, such as: fixed surveillance radar stations, patrolling and rescue ships, and most significantly, from

electronic tracking system with automatic identification (AIS) for vessels movement and remote sensing systems. Furthermore, these Big Data, processed under Machine Learning (ML) or more specific Deep Learning (DL) approaches/techniques with optimization modeling enables the VTS/MRCC operator to increase the control efficiency on tactical level actions and assess the risks/accidents impacts at sea. Such processed data enable the highly value information for sharing within CISE Network. While regarding the vessel route data (such as AIS), ML is one of the research trends for anomalies detection. In the following subchapters are taken in consideration the works related on both of these research areas.

3.1 Maritime Big Data applications for vessels detection

The AIS is a cooperative information system that provides identification and position of ships in real-time, but its coverage is limited by the structure of the system itself. The most effective solution to cover the remote ocean areas are space-based sensors, such as SAT-AIS (Helleren *et al.*, 2012). The AIS and SAT-AIS are the most used tracking systems in Maritime Surveillance, which have proven to help and support the resolution of many problems in this area, but even with global coverage, the AIS has its downside caused by the monitoring limitation of only reporting vessels. Thus, AIS should be integrated by other vessel tracking data sources. One of the shared Big Data sources alterative to AIS is provided by satellites remote sensing, such as earth observation satellites and Synthetic Aperture Radar (SAR). These images cover all the globe and contain also ships that do not share AIS information. But unlike AIS, information in optical images is not explicit, and a specific process is needed to be done to detect the vessel in the images. The vessel information extraction from satellite imageries is driven by 3 main processes: object or vessel recognition (finds a vessel in the image), vessel classification (the class of the vessel) and vessel identification (Kanjir *et al.*, 2018). The vessel recognition is the first step to extract vessel information from the images, it can exploit different types of algorithms, among these there is DL (Wang et al., 2018).

Even if in the past the image processing statistical techniques were more widespread, today it seems that the use of Neural Networks (NN) is gaining ground (Bentes et al., 2017), and in many works it is claimed that the latter provides advantages in terms of performance, and compared to statistics or even computer vision (Kanjir *et al.*, 2018). In the next step, the classification of the vessels in almost all recent works converge in the use of AI algorithms. Most of these classifiers seem to use Support Vector Machines (SVM), and in recent years the trend is also in favor of using NN here. Instead, other works focus on Bayesian networks and other statistics and AI

algorithms (Soldi *et al.,* 2021). The information extracted using satellite images can be more effective in combination to those collaborative systems such as AIS, which include identification and higher temporal resolution (Achiri *et al.,* 2018). Based on this information, it is possible to identify those vessels that omit the sending of AIS data, or that falsify them. In order to develop these operations, there exist different fusion techniques that have been studied (Fischer *et al.*, 2010). An important point of these technique is the usage of the interpolation on the AIS data, used to estimate the AIS position at the moment in which the vessel is extracted from the satellite image (Nguyen *et al.,* 2015).

3.2 Big data and AI solutions for maritime surveillance

In the previous chapter a series of information extraction techniques have been described, in this section the state of the art of anomaly detection algorithms are considered, grouping them by type of algorithms. SVM is one of the simpler machines learning methods, as it uses a separating hyperplane or a decision plane to demarcate decision boundaries among a set of data points classified with different labels. (Handayani *et al.* 2010) use SVM with Automated Identification System (AIS) from Port Kelang vessel, tracked for 3 months period and involving 367 tracks across 7 unique MMSI. By using these data, the paper assesses an accuracy of 90% of its techniques. Also, in (De Vries *et al.* 2012) SVMs is applied for detecting the outlying trajectories. The anomalies detection also takes advantage of Clustering, which is often used to extract patterns from the route and identify waypoints and classic routes. These routes, then, are used to describe the behavior of the vessels and to store this information in a sematic graph, that can be queried to find anomaly behavior as in (Varlamis el al. 2019).

Also (Dahlbom *et al.* 2007) explores trajectory clustering as a mean for representing the normal behavior of vessels. The approach uses spline-based clustering to overcome some issues in classical clustering. This approach breaks down the map into small zones where behavior patterns are detected. The most recent work that applies a similar approach is (Zhen *et al.* 2017) which executes a trajectory clustering, and then applies a Naïve Bayes classifier to detect anomalous vessel behavior. (Liu *et al.* 2015) separates the normal routes from AIS historical data and then extracts, using clustering, the normal trajectories and normal behaviors from that one with which the new data can be compared. The algorithms that have had the greatest growth and development in recent years are certainly those concerning NN in all variants, including also those that are defined as DL, which represents specific ML

model with multiple layers of non-linear processing units, referred to systems with numerous serially connected layers of parallel connected neurons.

In (Nguyen *et al.* 2018) trajectory reconstruction, the anomaly detection and vessel type identification are the tasks by which the deep framework proposed in the work is demonstrated to be applied with effectiveness. The algorithm uses a Recurrent Neural Network (RNN) with latent variables showing that this algorithm is particular suited for time series processing. The RNN is also used in (Zhao *et al.* 2019) which adopts a hybrid approach using also clustering DBSCAN algorithm to extract the traffic patterns and trains the RNN composed of Long Short-Term Memory (LSTM) units. The combination of clustering and NN seems to be an effective solution because the other works applied it, such as (Chen *et al.* 2019) where firstly it executes an OPTICS clustering to extract trajectory, and then applies convolutional NN in order to classify the trajectory. (Nguyen *et al.* 2021) uses a probabilistic RNN-based representation of AIS tracks, and then a grid-based threshold to assess the anomaly of the vessel. The grid threshold allows the algorithms to adapt the global classified behavior analysis to the local route trend.

Also, the other approaches used within maritime surveillance to detect the vessel anomaly are: Fuzzy ARTMAP NN, Gaussian Mixture Models (GMM), Bayesian networks for false ship type, etc (Svenmarck *et al.* 2018). A very interesting approach to identify the vessel are the Dynamic Bayesian Networks (DBN) that analyze the traffic situations at sea and assess kind of relationship between them. Specifically, in (Anneken *et al.*, 2019) this algorithm for identification of anomaly behaviors of vessels and reduction of unnecessary amount of data is elaborated according to the corresponding probabilistic model with graphical representation of Bayesian reasoning. In this approach, conditional probability is used with the time slices for random variables, that over time can obtain new attributes by passing from "parent-initial" to "child" situation. These changes can be abstracted as events with certain dependency rate, and if one event is realized, the others related will also happen in particular time interval. Applying this DBN to maritime environment and vessels as objects, the abstracted situations with random variables correspond to constituent events of vessel anomaly behavior as e.g. smuggling anomaly with particular attributes like position, vessel type, course, distance and approaching (Anneken *et al.*, 2019).

4 Case study: EU Project EFFECTOR

A significant EU research and innovation project related to maritime surveillance strengthening is *The End-to-end Interoperability Framework for Maritime Situational Awareness at Strategic and Tactical Operations* (EFFECTOR). This project gathers national maritime safety and security institutions, vessel satellite surveillance and data exchange software integrators, RTOs and academia with the aim to foster collaboration among stakeholders, using a common Interoperability Framework for Maritime Surveillance and Border Security. Some of important methods and tools used to increase the situational awareness in maritime domain are the following: multi-layered data lake platforms, data fusion and analytics, knowledge extraction and semantics, collision notification, maritime ontologies and vessel surveillance AI modules operated through integrated C2 systems/platforms (SeaMIS, ENGAGE, MUSCA) and in full compliance with CISE and EUROSUR standards. These innovative technologies are deployed, tested and validated in three operational trials: France, Portugal and Greece [EFFECTOR Grant Agreement, 2020]. Specifically, the end-user group, composed of governmental maritime safety and border authorities, provided relevant maritime data for Data Lakes collected from national LS for participation in the French, Greek and Portuguese Operational Scenarios and Trials, with final validation and evaluation of project technical solutions based on Key Performance Indicators. In this part, a soft information fusion and management toolbox and deployed in EFFECTOR project and then an Early Collision Notification System will be described. These AI features are used cinematic of vessels to take a decision.

4.1 A soft information fusion and management toolbox deployed in EFFECTOR project

Data and information fusion refer to a set of scientific methods and artificial intelligence algorithm to create or refine indicators by aggregating data from heterogeneous sources. More specifically in EFFECTOR project, the main function of fusion is enhancing situation awareness and reducing the number of information to be shared between different systems, increasing the global coherence of the information shared. Furthermore, as opposed to data, information embeds the context needed to be understood and interpreted. Within EFFECTOR, and for maritime safety in general, human operators are making decisions relying on the information they have access to. This is why we claim that the situation awareness of these operators should be improved thanks to semantic information, as it meaning is easily accessible to human operators. In this section, we describe the approach

used in EFFECTOR for semantic information fusion. Specifically, in the project EFFECTOR is deployed a soft information fusion and management toolbox, InSyTo, providing core generic functions for high level information fusion (Laudy, 2010). It was used on several projects ranging from crisis management (Laudy *et al.*, 2017) to investigation and oceanography, and we chose to use it in EFFECTOR for enhancing situational awareness and more particularly to detect meetings between several ships. The framework uses bipartite graphs and more specifically Basic Conceptual Graphs (Sowa, 1984; Chein and Mugnier, 2008) to represent information and knowledge. An ontology is used to adapt the toolbox for specific application domains. Basic conceptual graph are bipartite graphs containing concept and relation nodes.

The combination of core functions from InSyTo may provide advanced semantic information management functions. These core functions are depicted in Figure 2: Information Synthesis, Query and information fusion. The rectangle boxes represent concept node of conceptual graph and the circles represent relation of conceptual graph (between two concepts). The core functions of the toolbox are generic functions implemented over a generic maximal common subgraph (MCS) search algorithm. Depending on the way the MCS search algorithm is used, and on which parameters it is called, as illustrated in the Figure 2, several functions were developed such as information synthesis, information fusion, sub-graph fusion, information query, etc. To develop complex functionalities above InSyTo core function, one has to assemble them, and use them together with fusion strategies.

Fusion Strategies are domain and application specific rules used to provide the knowledge regarding compatibility of unit elements of the information graphs. Indeed, the fusion strategies are used to detect and fuse information items that are slightly different but describing the same situation. During an observation of an on-going situation, these differences may appear from using different sources of information with potentially different level of precision or points of view. The main goal of **sub-graph fusion** is to detect and fuse compatible parts of two graphs. As opposed to **information Synthesis** (top of Fig. 2), however, the result of the sub-graph fusion is only the common and fused part of the two graphs. One may see that, as the intersection of the two pieces of information.

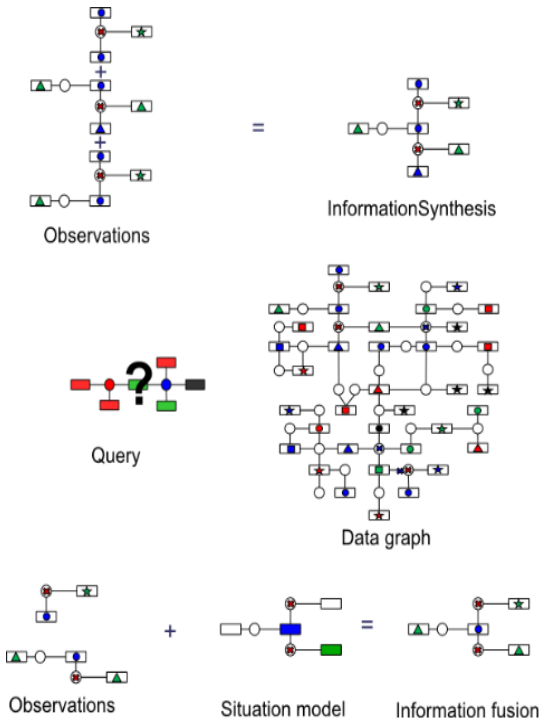


Figure 2: InSyTo core Function
Source: authors' adaptation

The **information query function** (middle of Fig. 2) can help to find all specified graph patterns within a Big Data graph. It is based on the search for injective homomorphism between the query graph and the data graph. The **information fusion** (bottom of Fig. 2) can help to find a specific situation model in observations. Within all the core functions of InSyTo, we added a traceability capacity (Laudy and Jacobé de Naurois, 2021). The aim is to keep records of all the fusion operations that were achieved on each unitary component of an information graph. The lineage graph records the initial source of each information item, as well as the succession of fusion operations together with the fusion strategies used. Adding this capability to the toolbox enabled us to improve the end user understanding and thus trust toward the overall system. For a specific use case, these different functions can be combined and specific strategy and similarity functions can be developed.

Also, trajectory fusion and abnormal vessel behavior is identified and managed in the EFFECTOR project using the InSyTo framework. More specifically, the suspicious vessel encounters are detected by a high-level fusion function,

implemented to reason on vessel trajectory data generated by AIS systems. The InSyTo sub-graph fusion function is used to detect common sectors of different vessel trajectories. Moreover, application and domain specific similarity functions and fusion strategies are implemented to define what a vessel encounter is.. A vessel encounter is considered suspicious if it lasts a minimum time duration and if the two vessels are at less at a defined geographical and temporal distance. A human operator further configures them to define the fusion conditions based on the specific application requirements. For the EFFECTOR case study, the InSyTo framework is connected to a Data Lake which contains vessels trajectories. After queries of vessel trajectories, the InSyTo framefork searches for encounter between vessels. Alerts in the CISE format are raised automatically to signal the beginning and the end of a suspicious vessel encounter, accompanied by the time and location data for each vessel pair involved. The two anomaly CISE types are "vessel approaching" and "vessel moving away". The InSyTo framework in EFFECTOR project is instantiated for automatically detecting risks and incidents and more specifically vessel encounter (or collisions). The goal is to enable better detection supports for operative agencies in maritime safety domain and efficient collaboration based on CISE network and architecture.

4.2 Early Collision Notification System architecture and deployment

Collisions at sea pose a significant threat with potential serious consequences for human life, environment and economy and maritime safety in general. To avoid these effects in an effective manner and reduce the implications of an imminent collision, much research has been conducted to evaluate the collision risk (CR) of two approaching vessels. Based on the value of this index early notifications can be generated to help seafarers execute the International Regulations for Preventing Collisions at Sea (COLREGS) avoidance maneuvers in time. Researchers have proposed many CR evaluation methods including numerical [Liu and Liu, 2006] and fuzzy comprehensive models [Feng and Li, 2012; Xu et al., 2009], ship domain methods [Xu and Wang, 2014; Szlapczynski and Szlapczynska, 2017], fuzzy reasoning methods [Kao et al., 2007; Rizogiannis and Thomopoulos, 2019] and other.

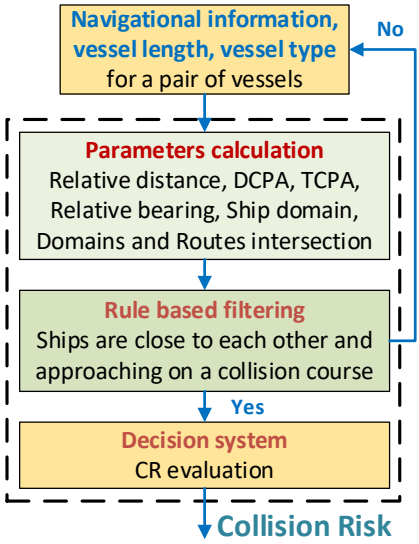


Figure 3: The high-level architecture of the ECNS

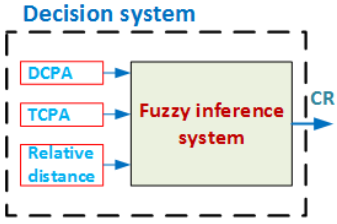


Figure 4: Block diagram of the ECNS decision module

In the context of the EFFECTOR project, the Early Collision Notification service (ECNS) has been developed as part of the EFFECTOR Multi-level data fusion and analytics services for knowledge extraction and provision of enhanced situational awareness. ECNS aims at timely generation of notifications of imminent collisions between ships that could cause death at sea in the area of operation. In this way ECNS service contributes to an increased level of maritime safety by providing, at an early stage, alerts and the necessary reaction time to avoid vessels collision. The high-level architecture and the decision engine of the ECNS service are presented in Figures 3 and 4 respectively. Compared to existing research, the proposed service was built aiming to quickly discard pairs of ships that appear no collision risk and minimize the number of variables used as input to the fuzzy system in order to

accelerate the decision process while at the same time achieve an efficient performance.

The input to the ECNS module is a rich set of data, containing kinematics information, (e.g. position, speed, course, turn rate, other) for the two most recently reported positions of both vessels as well as vessels' length and type. Using this input, many new parameters (e.g. Distance to Closest Point of Approach (DCPA), Time of Closest Point of Approach (TCPA), Relative bearing, other), are calculated, as well as other useful intelligence (e.g. routes intersection point, determination of encounter type, ships approaching or surpassing). At the Rule based filtering unit, the speed, course, routes intersection point, and distance information are used to determine whether vessels are close to each other and approaching on a collision course. If both conditions are valid the processing flow moves to the decision system where CR is evaluated. Otherwise, the ECNS service checks the next pair of vessels. Finally, in the decision system unit, a type-1 Fuzzy inference system (FIS) uses as input the set of variables (DCPA, TCPA, Relative distance) to evaluate the desired CR index where the membership functions (MFs) of both the input and the output variables are of the general form depicted in Figure 5.

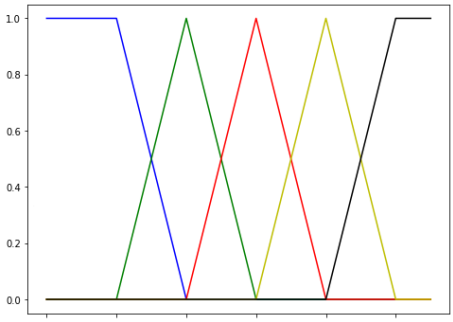


Figure 5: General form of the input and output variables MFs

5 Conclusion

The paper discusses some of the most important recent AI capabilities based on Big Data sources, and applied in maritime safety and surveillance in order to enhance the overall cooperation and performance of inter/national agencies involved in the CISE network. We analyze the key features of AI approaches, that improve the maritime surveillance using AIS and other data, and that, according to the augmented data/information fusion processes and decision support tools,

significantly contribute to the higher interoperability among maritime ICT systems and regional CISE cooperation of national agencies with purpose to enhance overall maritime safety. Specifically, the InSyto and ECNS tools deployed in EFFECTOR project concern the high level of development of AI-based fusion services for trajectory and movement tracking, necessary to detect vessel anomalous behaviour and assess the risk of possible vessel collision. Finally, we can conclude by saying that, maritime safety environment will achieve greater resilience and operational efficacy only by more intensive exploitation and combination of AI applications with advanced algorithms for vessel behaviour, risk events identification, assessment and control at sea and its timely, cost-effective exchange within CISE Network.

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FACTORS SHAPING THE CASHLESS PAYMENT ECOSYSTEM: UNDERSTANDING THE ROLE OF PARTICIPATING ACTORS

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Abstract Cashless payments have become increasingly popular around the world because of their numerous advantages. More so, the cashless payment adoption has been escalated during the Covid-19 pandemic. However, there is a lack of holistic studies on the adoption and contemporary practices of cashless payments. The purpose of this study is, therefore, to provide a comprehensive understanding by identifying the participating actors and their crucial role in the payment ecosystem. Thus, the paper aims to address two research questions: i) Who are the participating actors in the cashless payment ecosystem? and ii) What are the determinant factors for the actors to adopt the cashless payment ecosystem? Through scoping literature review of 63 articles published in the last seven years (2015-2021), six participating ecosystem actors are identified with their determinant factors. The study contributes towards addressing adoption issues and serves as a basis for future empirical investigation.

Keywords: cashless payment, actors, adoption factors, ecosystem, scoping review.

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1 Introduction

Due to the revolution of Information and Communication Technologies (ICTs) and the proliferation of the internet, we are witnessing an increasingly growing trend in cashless transactions (Fabris, 2019). Cashless payment means any type of electronic payment that is made without using physical currency (Sreenu, 2020). In a cashless society the use of cash has been minimised, and people mostly use non-cash payment instruments in conducting their transactions (Xena & Rahadi, 2019). In this context, it is a financial transaction in which the end-user does not need to have any cash in order to complete the purchase, and, instead, uses digital payment methods which can be broadly categorised into card payments, electronic payments, mobile payments (Rahman, Ismail, & Bahri, 2020) and cryptocurrencies (DeVries, 2016; Shahzad et al., 2018). Cashless payment adoptions vary in terms of maturity and penetration from country to country. In most developing countries, the adoption rates are marginal (Eelu & Nakakawa, 2018; Patil, Rana & Dwivedi, 2018). However, there are others such as Kenyan M-PESA and Ghanaian FinTech which have been successful in shaping financial inclusion (Senyo et al., 2022; Van Hove & Dubus, 2019). In the Scandinavian countries, the cashless payment systems have become a norm. For instance, Sweden is becoming the world's first cashless society and serves as a role model for many countries (Engert & Fung, 2017; Fourtane, 2020).

Cashless payments have become the crucial component of the global economy (Kabir, Saidin, & Ahmi, 2017), and increase in access and usage of cashless payment leads fairly directly to an increase in economic growth (APEC, 2015). Going cashless is a global trend because adopting cashless payment has numerous benefits, such as helping to reduce suspicious transactions of money, circulation of fake currency, and combating money laundering to crackdown on organised crime (Arvidsson, 2019a; Jamsheer, 2018). Moreover, Covid-19 has changed consumer payment preferences. For example, digital wallets and 'Buy Now Pay Later' (BNPL) are taking the world by storm while cash payment is taking a backseat (Worldpay, 2021). Many countries began to experience a rise in cashless transactions during the pandemic as they changed to cashless methods of payment to reduce the risk of infection from handling cash (Jaafar, 2020). As per the Global Payments Report, the use of cash has reduced by 32% since 2019. Consumers are moving away from cash with record speed and the pandemic has accelerated the decline of cash by 42% over three years (Worldpay, 2021), whereas, electronic payment has seen the highest growth rate in

five years at 19%. The ever increasing cashless payment frequency comprises electronic money being injected into the global intertwined system, which consists of multiple actors. The new era demands platformification, and firms can unleash full market potential by embracing open ecosystems (Capgemini, 2022). This stimulates us to identify the relevant actors and better understand their determinant factors as the cashless payment ecosystem is central in today's society (Henningsson & Hedman, 2014). It is necessary to develop the theoretical achievement against the pragmatic nature of the cashless payments as it has become one of the society's most innovative and dynamic sectors with technology-led competition as the new normal (Hedman & Henningsson, 2015).

There is ample research on the adoption of cashless payment (e.g., Manrai, Goel & Yadav, 2021; Patil et al., 2018; Qiu, Shi & Zheng, 2019). These studies frequently used well-established technology diffusion theories such as Technology Acceptance Model (TAM) (Davis, 1989), Unified Theory of Adoption and Use of Technology (UTAUT) (Venkatesh et al., 2003) or an extension of these two theories (e.g., Salloum & Al-Emran, 2018) to examine the factors influencing the adoption of cashless payment. However, the models are limited to studying how users come to adopt and accept a technology like cashless payment systems. The influencing factors found through these models are not sufficient to establish a sustainable multi-sided market of cashless payment. There is a lack of insight into the roles of the participating actors in the ecosystem. Moreover, the previously developed conceptual models from adoption factors are either integration of other models or single actor-focused. For instance, Jaafar (2020) integrated UTAUT and the Health Benefit Model to evaluate the adoption of e-payments and Oney, Guven and Rizvi (2017) developed a conceptual model to examine the same from consumers' perspective. Guo and Bouwman (2016) developed a three-tier mobile payment ecosystem model from the merchants' perspective. Senyo et al. (2022), on the other hand, focused on the payment service providers' perspective such as FinTech ecosystem whereas Eelu and Nakakawa (2018) designed a framework towards adoption of e-payment in a developing economy by extending TAM model.

According to our literature search, there is a lack of model which captures a holistic view of the cashless payment ecosystem and highlights the critical roles of different actors involved. This study, therefore, aims to provide a comprehensive view about the crucial role of the actors in the cashless payment ecosystem and factors that

influence their adoption. As such, through the scoping review method, this paper addresses to answer two research questions: *i) Who are the participating actors in the cashless payment ecosystem?* and *ii) What are the determinant factors for the actors to adopt the cashless payment ecosystem?*

2 Methodology

This study followed a scoping review process suggested by Peters et al. (2015). Scoping review is an appropriate approach for seeking and mapping the evidence in broad topic areas, particularly to identify and examine factors related to a particular concept (Peters et al., 2015). It aims to map the key concepts underpinning the research area, especially where the research area is complex or has not previously been comprehensively reviewed. Through the use of scoping review, we are able to inform a best practice model (Munn et al., 2018) and identify the concepts in the studies, and be able to map, report or discuss the generated concepts (Arksey & O'Malley, 2005).

2.1 Search strategy

The search process was initially conducted using two scientific databases - Web of Science and Scopus, and then complemented the search with Google Scholar to include grey literature such as company white papers and reports. For the purpose of accuracy and reach and to get only the relevant articles that focus on the factors of cashless payment, the keywords were combined using the search string AND/OR operators and wild card "*" was used to include possible segments after the phrase which produced the following search strings: ("cashless payment*" OR "digital payment*" OR "electronic payment*" OR e-payment* OR "contactless payment*" OR "mobile payment*" OR "paperless payment*") AND (factor* OR determinant*) AND (society* OR ecosystem*). We searched these keywords in the title for the quest for accuracy in the search results. The articles were selected based on the following five criteria: i) Journal articles and conference proceedings published during the past seven years (2015-2021) complemented by the latest company whitepapers, to focus our review on contemporary literature; ii) Written in English; iii) Discussing the determinant factors of cashless payment systems; iv) Studies on adoption, use and acceptance of cashless payment systems; and v) Full-text content access for reading and downloading.

The initial search retrieved 183 articles in total. After removing the duplicates, 104 articles remained for examination. We applied criteria iii, iv and v through reading the articles' title and abstract and excluded 25 articles that did not fulfil the set criteria and another 7 articles were removed because the full content of those articles was not accessible for reading. Seventy-two full-text articles were assessed by applying criteria iii and iv through a thorough reading of the articles' full content and examining the aims and objectives, methods, results and conclusions to mainly assess the quality of the paper. Sixteen articles were excluded because the studies proved irrelevant to the objective of this study as they either discussed technical aspects or factors affecting the 'continuance usage intention' of digital payment (e.g., Ayo et al., 2021; Poerjoto, Gui, & Deniswara, 2021). Fifty-six articles remained after assessing the eligibility. The final list of articles was gathered after conducting snowball sampling by searching through the references of these 56 articles. Another 7 new articles were added and, in total, by combining these two sets of relevant articles, 63 articles were finally included for this review.

2.2 Data analysis

The study focused on generating concepts by synthesising existing research on the adoption of cashless payment systems. Data from the selected 63 articles have been extracted for the scoping review referred to as "charting the results". The data were extracted into a draft charting table (excel sheet) developed to record characteristics of the included studies and the key information relevant to the research questions (e.g., study aims, actors, determinants or factors, key concepts, and findings, etc.). The study used concept mapping as a general method to describe the cashless payment ecosystem in a more comprehensive and holistic visual diagrammatic form. Thus, concepts required to explain & describe the payment ecosystem were mapped out and the results were presented as a 'map' of data in a tabular and diagrammatic format (see Figure 1). Open coding was utilised whereby we carefully scrutinised all the selected articles and recorded the determinant factors and ultimately contrasted these concepts and grouped them under the identified actors based on their relevance and relationships.

3 Results and Discussions

In this section, we detail the results based on our two research questions.

3.1 Participating actors of the cashless payment ecosystem

According to (Walsham, 1997), actors can be both human and nonhuman, such as technological artefacts linked by associations of heterogeneous networks of aligned interests, including people, organisations and standards. At the centre of every ecosystem, an actor is capable of using structural capabilities to interact in creative or innovative ways in order to co-create value (Tronvoll, 2017). An ecosystem consists of a set of interdependent actors and factors coordinated in a particular way whereby they enable productive innovation (Stam & Spigel, 2016). We have found that digital payments have become a popular spot for innovation. It is not only the internet giants, such as Google, Apple, Facebook, and Alipay, and FinTech companies, such as PayPal, Square, iZettle, etc., who have entered the market, but also, there are other prominent actors who contribute to the whole ecosystem. Thus, through synthesis of the retrieved articles, we identified the following six participating actors.

Consumers include the end-users, such as individuals, organisations, etc., who benefit from using the cashless payment systems. They are considered as the trigger of a cashless ecosystem (Liu, Kauffman, & Ma, 2015). Their acceptance and usage can trigger other actors to adopt cashless payments. For them, cashless payment can increase convenience, save time, and allow them to experience new innovations (Acheampong, 2017).

Merchants are the businesses such as 'brick-and-mortar' and other retailers etc., who accept cashless payment. The digital payment market is multi-sided as such a payment method being adopted by consumers should be accepted by merchants and other stakeholders to be used for transactions.

Service providers refer to the various entities who have a business interest in replacing cash payments with electronic payments (Arvidsson, 2019b). These industries include conventional banks; nonbanks; Fintech companies; card providers like Visa and Mastercard; telecom companies such as Apple and Samsung; e-

commerce companies like Alibaba and Amazon; cryptocurrency providers as well as providers of hardware and software solutions for electronic payments (Arvidsson, 2019a).

Media and content promoters are among the important players of the ecosystem that can greatly influence and promote cashless payments. A large majority of the online public are communicating through a new medium called 'social media' where members share, engage and collaborate with their peer groups to build lasting relationships in the virtual world. Some of the popular social media sites include mainstream social networking sites like Facebook and Google, professional networking sites like LinkedIn, blogs like WordPress and BlogSpot, video sharing websites like YouTube, microblogging sites like Twitter etc.

Regulators and policymakers are critical participants of the cashless payment ecosystem. The actors include the regulatory bodies and policymakers such as central banks and other governmental financial institutions related to the legislature of payment services (Senyo et al., 2022). These actors mainly create safe and conducive environments for the other ecosystem participants to thrive.

Infrastructure is one of the main drivers for the ecosystem and is about building a secure and reliable physical network to provide cashless payment nationwide. It plays a major role in expansion of cashless payment services which include internet connectivity, power supply, cloud computing, blockchain, cybersecurity, etc. Cashless payment itself is a technology which does not involve physical cash as the payment is done through electronic medium (Vinitha & Vasantha, 2017). Infrastructure becomes the key player as consumers and merchants demand safeguards from fraud and identity theft (Capgemini, 2022).

These six actors as described above are interlinked, and each actor has a participating role in the ecosystem in terms of collaboration and coopetition, which is essential as their roles determine the factors influencing the adoption of cashless payment (Błach & Klimontowicz, 2021). The next section presents the factors determining their adoption of the cashless payment ecosystem.

3.2 Determinant factors for the adoption of cashless payment ecosystem

Table 1-6 below shows the factors that determine cashless payment adoption for each actor with references.

3.2.1 Consumers

Out of 63 studies reviewed, 31 articles investigated factors influencing consumers' adoption (Table 1). Most articles discussed *'trust'* and *'security'* as the factor for consumers' adoption of cashless payment systems (e.g., Shahzad et al., 2018; Barkhordari et al., 2017; Patil et al., 2018; Qiu et al., 2019). The effects of trust and security on the use of cashless payment have long been recognised in e-commerce literature. This is mainly because the transactions are done through electronic medium using technology such as cryptocurrency like bitcoin (Shahzad et al., 2018) and others which does not involve physical cash (Vinitha & Vasantha, 2017). This is also the reason why it is an unavoidable fact that *'perceived risk'* is associated with the cashless payment systems and influences the adoption decision of the consumers (e.g., Dahab & Bouqlila, 2022; Singh et al., 2019).

The users' trust factor is also impacted by other adoption factors such as system quality, service quality and information quality (e.g., Jocevskia, Ghezzib, & Arvidsson, 2020; Tiwari & Singh, 2019). Trust related to payments is closely linked to information security and data privacy of consumers when making transactions in e-commerce (Sutia et al., 2020). Consumers have a greater tendency to adopt cashless payment when they feel secure about their personal information shared through cashless payment systems. Therefore, cybersecurity is critical as payment data become agile in the open finance future (Capgemini, 2022). Further, past experience has been found to be the common determinants of perceived security and trust (e.g., Dahab & Bouqlila, 2022; Oney et al., 2017; Singh et al., 2019). Consumers' trust is also affected by their own acquaintance; they trust electronic payment tools they know better (Zizhou et al., 2019).

Existing technology diffusion theories (e.g., TAM and UTAUT) have been extensively used to examine consumer' adoption of cashless payment (e.g., Al-Okaily et al., 2020; Manrai et al., 2021). The *'perceived usefulness'* and *'ease of use'* were the most important factors highly associated with the adoption of cashless payment systems

(e.g., Al-Dmour et al., 2021; Frączek & Urbanek, 2021). For instance, "perceived ease of use" is a significant factor influencing consumers' use of tap-and-go payment in the USA (Bailey et al., 2020; Chadha, 2018).

Table 1: Determinant factors for Consumers

Factors	References
-Trust & Security - Perceived Risk - Data privacy - Ease of Use - Performance expectancy - Social influence - Facilitating conditions - Cost - Demography	Dahab and Bouqlila (2022); Mahmoud and Yaseen (2021); Qiu et al., 2019; Patil et al. (2018); Shahzad et al. (2018); Barkhordari et al. (2017); Oney et al. (2017); Rohimah et al. (2019); Al-Okaily et al. (2020); Sutia et al. (2020); Mensah et al. (2021); Singh et al. (2019); Vinitha and Vasantha (2017); Frączek and Urbanek (2021); Al-Dmour et al. (2021); Ladkoom and Thanasopon (2020); Kabir et al. (2017); Kumar et al. (2020); Rahman et al. (2020); Ibidunmoye (2018); Manrai et al. (2021); Arvidsson et al. (2016); Jocevskia et al. (2020); Capgemini (2022); Swiecka et al., 2021; Nadler et al., 2019; Lohana and Roy (2021); Khurana et al. (2019), Tiwari and Singh (2019); Bailey et al. (2020); Chadha (2018)

The consumers' adoption to cashless payment is positively influenced by performance expectancy (PE), social influence and price value. PE means, the individual believes that using the cashless payment system will help to attain gains in work performance (Venkatesh et al., 2003) which is similar to the perceived usefulness factor. There is a positive relationship between PE and adoption of cashless payment systems. Consumers who believe cashless payments will increase their overall work performance are willing to adopt cashless payments (e.g., Al-Okaily et al., 2020; Mensah et al., 2021). The 'social influence' factor, "the degree to which an individual perceives the importance of others to believe that he or she should use the new system" (Venkatesh et al., 2003, p. 451) serves as the determinant for consumers to frequently use cashless payment. Similarly, other peoples' views and opinions such as peers' and friends' opinions play an important role in the acceptance of cashless payment (e.g., Singh et al., 2019; Ibidunmoye, 2018).

The 'price value or cost' is an important factor when it comes to consumers' choice of cashless payment systems such as mobile payment (Al-Okaily et al., 2020). This factor is consistent with many other studies (e.g., Jocevskia et al., 2020; Kabir et al., 2017; Zizhou et al., 2019). Similarly, 'facilitating conditions' are necessary to use cashless payments (Rahman et al., 2020). The more consumers have knowledge and resources to use cashless payment, the more they are willing to adopt it. This finding is also in line with other researchers (e.g., Al-Okaily et al., 2020; Manrai et al., 2021). Further, the demographic factors influence consumers' adoption (e.g., Gong et al., 2017; Khurana et al., 2019; Lohana & Roy, 2021). For instance, education level as an individual demographic variable has a significant relationship with the intention of the adoption of cashless payment service while age and gender were found insignificant (Al-Dmour et al., (2021).

3.2.2 Merchants

Out of 63 studies, 10 discussed factors influencing merchants' cashless payment adoption (Table 2). Since merchants are mostly profit-oriented businesses, their choice of payment service largely depends on direct 'cost' and 'revenue' of each payment service (Arvidsson, Hedman, & Segendorf, 2016). The other important factors that determine their decision to accept cashless payment include merchants' background, such as age, number of credit cards held, use of computers, etc. and merchants' business characteristics (e.g., business sector they belong to, total value of transactions per month, average value of transaction, profit margin, location of business) and effects of other players' decisions via the merchant' s perception (including the merchant's perception of customers' use of cards and competitors' participation in the card scheme). There is positive relationship between merchants' stated preferences with consumers' revealed preferences (Huynh, Nicholls, & Nicholson, 2019). Studies on small and medium-sized businesses (SMBs) focusing on SMBs' adoption of contactless payments apps including Apple Pay, Masterpass, WeChat Pay and Alipay etc. show that merchants often perceived credit cards to be most costly in terms of fees and concluded that merchants' adoption of cashless payment is highly determined by cost and revenue (Arvidsson et al., 2016; Huynh et al., 2019; Kosse et al. 2017).

Table 2: Determinant factors for merchants

Factors	References
-Cost & Revenue -Trust & Security -Perceived Risk -Perceived usefulness -Perceived ease of use -Merchants' background (e.g. age, number of credit cards held, use of computers) -Business characteristics (e.g. sector it belongs, value of transaction, profit margin, business location) -Merchants' perception (on customers' use of cards and competitors' participation in the card scheme)	Nuryyev et al. (2021); Arvidsson et al. (2016); Moghavvemi et al. (2021); Xena and Rahadi (2019); Huynh et al. (2019); Kosse et al. (2017); Fontes et al. (2017); Jonker (2018); Frączek and Urbanek (2021); Yeboah et al. (2020)

The cost and revenue factors are also applicable for merchants who adopt cryptocurrency payments. The other factors related to their cryptocurrency adoption include 'consumer demand' where consumers desire to pay with cryptocurrencies, 'lower transaction cost' and 'perceived efforts' required for the adoption (Jonker, 2018). Similarly, cryptocurrency payment adoption by merchants in the hospitality business was influenced by 'perceived usefulness' which in turn is affected by trust, risk, and security and 'perceived ease of use' which is affected by risk and convenience (Nuryyev et al., 2021). Similar factors were also found true for the merchants from passenger transport of European Union countries (Fontes et al., 2017; Frączek & Urbanek, 2021).

One of the most used factors affecting the merchants' adoption of digital payment is the 'perceived risk' which is defined as "the potential for loss in pursuit of a desired outcome of using an e-services" (Featherman & Pavlou, 2003, p. 454) as "the uncertainty about what the innovation gives" (Gerrard & Cunningham, 2003, p. 19). Risk is one of the main reasons why merchants avoid a new digital payment system like cryptocurrency. Perceived risk of cashless payment technologies includes security risk, third party service failure risk, risk of user error, risk of privacy loss, risk of counterparty fraud, and risk of illicit association (Nuryyev et al., 2021). For example, perceived risk of a cryptocurrency payment negatively impacts perceived

security, which is considered a strong predictor for a new payment technology adoption (Fontes et al., 2017).

The determinants such as payment processing time and fees, convenience and enhanced payment security features are motivating merchants to adopt m-payment while technological incompatibility, complexity, the cost of investment and the lack of critical mass and knowledge are some of the factors discouraging merchants (e.g., Moghavvemi et al., 2021). Therefore, service providers and technology characteristics are considered the two dimensions that could influence merchant adoption. For instance, 'trust' is a critical factor for merchants' adoption due to the security risk. Thus, sufficient trust-building strategies from service providers are essential for adoption of mobile payment by merchants (e.g., Yeboah et al., 2020).

3.2.3 Service providers

Out of 63 articles reviewed, 16 discussed factors influencing service providers' adoption of cashless payments (Table 3). Payment service providers ensure that the services they provide are simple and friendly to operate, satisfy customers' needs, build trust by protecting accounts from frauds and make the payment affordable to positively influence consumers and other stakeholders to adopt payment services (Narteh, Mahmoud, & Amoh, 2017). Moreover, new technologies and innovations have opened up opportunities for service providers to enter the cashless payment ecosystem. Thus, one of the main factors for them to adopt cashless payment will largely depend on their *'capacity to innovate'* (APEC, 2015; Senyo et al., 2022). This factor, which concerns the innovative products and services, is stimulated by change in regulations and presence of payment infrastructure. For example, in Sweden, the second Payment Service Directive (PSD2) issued by the European Union is changing the payment landscape. The PSD2 is aimed at increasing competition and to stimulate innovation by institutionalising payment industries characterised by open banking (Arvidsson, 2019b; Waalan & Olsen, 2019). This open banking concept creates open platforms whereby payment service providers such as conventional banks and FinTech companies provide competitive services from which consumers and merchants can select payment services as per their own preference. Thus, meeting the *'consumer and merchant satisfaction level'* in terms of '*supplying competitive services'* becomes a determinant factor for the service providers to take part in the cashless payment ecosystem (Arvidsson, 2019b; Tiwari & Singh,

2019). Service providers also nurture merchants' trust because merchant trust in them acts as a fundamental enabler for the adoption of digital payments (e.g., Arvidsson, 2019b; Yeboah et al., 2020).

Table 3: Determinant factors for Service Providers

Factors	References
- Capacity to innovate - Consumer and merchant satisfaction level - Supplying competitive services - Collaborative practices - Customer base - Marketing capabilities	Bailey et al. (2020); Chadha (2018); The Federal Reserve (2022); Nery (2021); Ozili (2021); Engert and Fung (2017); Ozturkcan (2019); Armelius et al. (2020); Söderberg (2019); Waalan and Olsen. (2019); Arvidsson (2019b); APEC (2015); Senyo et al. (2022); Tiwari and Singh (2019), Yeboah et al. (2020); Narteh et al. (2017)

The other factor affecting cashless payment adoption for service providers such as FinTech firms, Telcos and banks is the *'collaborative practices'* whereby they have to build relationships amongst the stakeholders and subscribe to a collaborative model to deliver innovative payment service (Senyo et al., 2022). Collaboration between the cashless payment ecosystem actors is necessary to realise coopetition, i.e., stimulating competition while at the same time ensuring the growth of cashless platforms that yield economies of scale and scope as well as interoperability and open access. The service providers' determinants, such as *competition and innovation* can stimulate start-ups in the FinTech and Regtech industries, e.g., related to cryptocurrency technologies such as blockchains (APEC, 2015; Arvidsson, 2019b). The central banks across the world have started launching national digital currencies to replace cash and have become one of the cashless payment service providers. This development not only fosters competition and innovation but also ensures the fundamental security and efficiency of the monetary system (Armelius et al., 2020; Ozturkcan et al., 2019).

The factors such as *'presence of foreign competitors'* could be the trigger because the entrance of large IT companies, such as Google, Apple and Facebook, into the payment market are increasingly issuing their own private digital currencies. For

example, in Sweden, the central bank is issuing its own digital currency in competition since a successful penetration by a multinational digital currency would pose a fundamental challenge to the Swedish monetary system. Launching an e-krona would help ensure that all individuals have access to an efficient, convenient, and secure means of payment (Armelius et al., 2020; Ozturkcan et al., 2019). The central banks have an interest in the efficiency of the payments system and, as a payment service provider, they are influenced by factors of *'increase in contestability and efficiency in payments'* (Engert & Fung., 2017). They are also motivated by other factors such as 'promotion of financial inclusion' (Ozili, 2021), especially in developing countries. There are also examples of other payment systems providing financial inclusion besides the central banks such as M-PESA in Kenya and Modelo in Peru (Engert & Fung, 2017).

The nonbank e-money providers are another form of payment service providers. Nonbanks are not licensed as banks but provide loans, money transfers and other financial services that are normally offered by conventional banks. They include financial institutions such as insurance companies and pension funds, finance companies, broker-dealers, money market funds, hedge funds, other investment funds and central counterparties (Aldasoro, Huang, & Kemp, 2020). "Nonbank money is digital money held as balances at nonbank financial service providers" (The Federal Reserve, 2022, p.5). They conduct balance transfers on their own books using a range of technologies such as mobile apps (The Federal Reserve, 2022). M-PESA e-payment is an admirable success story which has expanded access to basic financial services to millions of underserved Kenyans in Africa (Nery, 2021). Its financial service provider, Safaricom, Kenya's largest mobile network operator, was able to reach the customers with affordable payment service because of three success factors, namely, their existing customer base, marketing capabilities and physical distribution infrastructure (Nery, 2021).

3.2.4 Media and content promoters

The media and content promoters are critical for the payment ecosystem to promote and market cashless payment systems. Eight studies have discussed their adoption factors (Table 4). For example, Singh et al. (2019) drew insights from Twitter analytics to study adoption of digital payments in India and found that social media marketing is used for the promotion of digital payment systems. Twitter is

extensively used by payment service providers to make the consumers aware of their products as well as using Twitter as a platform to promote themselves (Singh et al., 2019).

Table 4: Determinant factors for media and content promoters

Factors	References
- Point-of-purchase communication - Reassurance advertising e.g., TV commercials - Social influence e.g., Experts' opinions, Social media influencers, Word-Of-Mouth - Awareness of Products & Services - Awareness of Payment Technology	Singh et al. (2019); Narteh et al. (2017); Koenig-Lewis et al. (2015); Darma and Noviana (2020); Kalinic and Marinkovic (2016); Bailey et al. (2020); Kaur et al. (2020); Nguyen (2018)

Apart from the social media networking, the cashless payment service providers use different communication channels to deliver messages such as *'Point-of-purchase communication'* where payment service providers like banks, FinTech companies, Telcos, etc., display banners, posters and billboards that highlight the advantages of cashless payments. The digital payment products and services are also promoted through catalogues, booklets and leaflets containing clear information about the available services targeted to the consumers in retail stores, bank offices, shopping malls, cinemas and mobile phone stores (Nguyen, 2018). Promotions are also distributed through television as 'TV commercials' and on the radio. The cashless payment providers incorporate their services in TV programmes, movies, and financial and technological events to reach out to their consumers recommending available payment technologies (Nguyen, 2018). For instance, it was found that attitude towards digital payment was negatively impacted by perceived risk and trust; therefore, service providers use 'TV commercials' to show that digital payment systems are being accepted by various retailers and used by other consumers. This reassurance advertising proved persuasive given that socio-cultural influence also has a strong influence on attitude towards cashless payment (e.g., Bailey et al., 2020).

One of the factors related to Media and Content Promoters is the 'social influence' (Narteh, Mahmoud, & Amoh, 2017; Bailey et al., 2020). This includes both external and interpersonal social influence. External social influence includes non-personal information such as mass media reports, expert opinions, etc., and the interpersonal

social influence refers to word-of-mouth from peer groups (Bailey et al., 2020; Kaur et al., 2020). For example, social influence had a positive impact on use of e-payment among Serbian consumers (Kalinic & Marinkovic, 2016) and reduced the perceived risk of mobile payment adoption among young French consumers (Koenig-Lewis et al., 2015).

3.2.5 Regulators and Policymakers

Fourteen articles discussed regulators and policymakers as participants in the cashless payment ecosystem (Table 5). They are critical for the smooth functioning of ecosystem. These actors frame the payment system policies and regulate them. The US Federal Reserve report 2022 states that for a nation's economy to function smoothly, the citizens must have confidence in the nation's money and payment services. The central banks as regulators work towards maintaining public trust and confidence by fostering monetary and financial stability and implementing safe and efficient payment system (The Federal Reserve, 2022). Thus, a *well-functioning and trustworthy payment policy framework* should be assured by the central bank which is viewed as a public good that warrants direct involvement of the regulatory body of the state. The government as a statutory body maintains a stable store of value and unit of account, and ensures that the payment system is safe, efficient and inclusive (Armelius et al., 2020; Senyo et al., 2022; The Federal Reserve, 2022). Further, the government has the role to protect personal integrity by ensuring that personal data generated by commercial companies during the purchases are not stored and misused for commercial purposes (Armelius et al., 2020).

Table 5: Determinant factors for Regulators and Policymakers

Factors	References
- Policy framework (Well-functioning and trustworthy payment policy) - Financial inclusion Policy - IT Governance - Conducive environment - Effective legal system	Danchev et al. (2020); Rohimah et al. (2019); Soutter et al. (2019); Singh et al. (2019); Senyo et al. (2022); Akanfe, Valecha, and Rao (2020); Arvidsson (2019a); The Federal Reserve, 2022; Armelius et al., 2020; Waalan and Olsen. (2019); Singh et al. (2018); Nguyen (2018); Kaur et al. (2020); Xena and Rahadi (2019); Ladkoom and Thanasopon (2020)

The policy makers such as governments or central banks should be context specific, sensitive and have a positive impact on the other actors of the ecosystem. They work in coordination with the other players, like private and public financial institutions and payment service providers, to frame policies on innovative technology systems (Singh et al., 2018).

The regulators and policymakers establish a payment system that works for all individuals in society. They ensure regulations in place to build ICT infrastructure through which payment service providers can provide affordable and secure cashless payment systems. In the same way, through policy change, the policymakers create *'conducive environments'* for the new businesses to foster market entry which enhance cashless payment solutions. They also focus on implementing efficient legal framework whereby it takes less time and resource in settling disputes related to cashless payment systems (APEC, 2015). Financial inclusion (Frączek & Urbanek, 2021; Kabakova & Plaksenkov, 2018) is one of the primary factors for the policymakers when it comes to policy implementation relating to cashless payment systems. The financial inclusion policy and regulatory issues exist not only in the developing countries but also prevail in the developed cashless leading nations (Waalan & Olsen., 2019). Certain groups in society, such as the elderly and groups with different forms of disability, find it hard to pay with digital forms of payment. Moreover, in some countries, most retailers no longer accept cash as a payment (Waalan & Olsen., 2019). Therefore, it is the role of the governments or policymakers to develop policies ensuring financial inclusion for everyone in the society. The situation of digital divide leading to financial exclusion is unacceptable (Arvidsson, 2019a). Furthermore, payments run on trust; thus, it is crucial to enforce regulation and laws which ensure privacy and integrity for people to use digital payments (Arvidsson, 2019a). For example, Thai government initiated 'PromptPay' a national e-payment initiative to reduce the use of cash and catalyze the adoption of e-payment (Ladkoom & Thanasopon, 2020). Similarly, in Ghana, the Ghanaian central bank as a regulating body supported FinTech companies through providing licensing regime to regulate the payment ecosystem (Senyo et al. 2022).

3.2.6 Infrastructure

Eight studies highlighted the importance of infrastructure as a participating actor of cashless payment ecosystem (Table 6). The infrastructure in the context of digital platforms constitutes large-scale socio-technical projects that are aimed at the ubiquitous and reliable provision of a service (Plantin & De Seta, 2019). The internet network connectivity, smartphone penetration, power supply, biometrics, tokenisation, cloud computing, blockchain, cybersecurity, wearable technology, and the Internet of Things, etc., are some of the infrastructures relevant for cashless payments.

The 'internet connectivity' is essential for the cashless society to thrive and this is highlighted by many researchers (e.g., Jocevskia et al., 2020; Singh et al., 2018; Soutter et al., 2019). For example, the 'Chinese internet' is dominated by the search engine Baidu, an e-commerce site Alibaba, and a messaging software Tencent. These three internet companies operate and serve as an internet service provider for other infrastructural domains such as artificial intelligence, cloud computing, mobile payments and other financial services, etc., similar to Alphabet, Amazon and Facebook in the USA (Plantin & De Seta, 2019).

Table 6: Determinant factors for infrastructure

Factors	References
- Internet network connectivity (Smooth Payment network) - Digital ID scheme, - Biometrics - Cloud computing - Blockchain - Cybersecurity	Soutter et al. (2019); Singh et al. (2018); Vinitha and Vasantha (2020); Frączek and Urbanek (2021); Jocevskia et al. (2020); APEC (2015); Capgemini (2022); Plantin and De Seta (2019)

Infrastructure plays a key role in safeguarding consumers and merchants from fraud and identity theft. For example, contactless payments' popularity during the pandemic has prompted the need for a robust digital ID infrastructure (Capgemini, 2022). According to the World Payment Report 2022, digital ID infrastructure will be the key as payments become transparent (Capgemini, 2022). Across the world, governments are launching national identity initiatives. For instance, the European

Commission will be launching an identity verification toolbox by September, 2022 and several other countries like Australia, Canada and New Zealand are following through. These infrastructural changes in the payment industry will help unify access and will facilitate regulations such as PSD2 and open banking to thrive on a shared and integrated digital ID scheme. For example, the National Institute of Standards and Technology (NIST) in the United States published new Digital Identity Guidelines (SP 800-63-3) to incorporate 'biometrics' for password-less authentication (Capgemini, 2022).

3.3 The Ecosystem

As shown in Figure 1, the cashless payment ecosystem has been brought into existence through the convergence of six actors with individual factors that determine their adoption of cashless payment. The first two actors, consumers and merchants, focus mainly on the actual 'demand side' of the cashless payment ecosystem as their adoption and usage of cashless payment are key to the thriving cashless payment ecosystem. They are influenced by the economic use of the various cashless payment technologies such as card payments, e-payments, mobile payments, cryptocurrencies. The factors such as trust and privacy, security and risk, cost and revenue, and 'ease of use' and usefulness; influence them to adopt the cashless payment system (e.g., Nuryyev et al., 2021; Qiu et al., 2019; Patil et al., 2018). On the other hand, the third actor, 'payment service providers', and fourth, 'media and content promoter' generally fall under the 'supply-side' of the cashless payment ecosystem.

Their adoption of cashless payment is influenced by economies' readiness to develop innovative cashless payment products and services. Their participation in the ecosystem is influenced by factors such as level of competitiveness, capacity to innovate, marketing capabilities, consumer and merchant satisfaction level, awareness of products and services (Bailey et al., 2020; Chadha, 2018; The Federal Reserve, 2022; Nery, 2021).

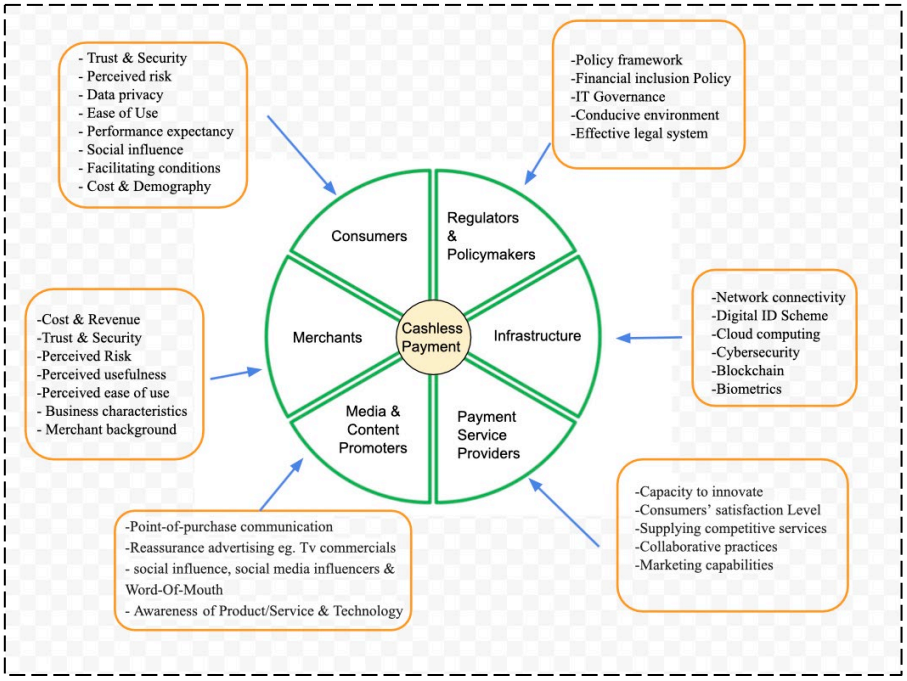


Figure 1: Determinant factors for the adoption of Cashless payment ecosystem

The fifth actor, regulators and policymakers focus on framing cashless payment system policies and regulations for smooth functioning and creating conducive environment. They provide the necessary IT governance and put in place the regulations and policies needed to build cashless payment infrastructure through which affordable and secure payment services can be provided. One of the main factors that determine the role of policymakers in the adoption of cashless payment system is that they implement payment policies that work for all, thus, financial inclusion policy is considered a critical factor when building cashless payment systems (e.g., Frączek & Urbanek, 2021; Kabakova & Plaksenkov, 2018). The cashless payment infrastructure is the sixth participating actor of the ecosystem. The expansion of cashless payment system mainly depends on reliable and secure physical network to cater across the society. The focus is on the reach and making available of the fundamental services required for the cashless payment system such as internet network connectivity, digital ID scheme, cloud computing, cybersecurity, blockchain etc.

4 Conclusion

With the use of scoping literature review, six participating interlinked actors of the cashless payment ecosystem are identified: consumers, merchants, service providers, media & content promoters, regulators & policymakers, and infrastructure. These six key actors are considered to be the building blocks of a cashless payment ecosystem.. The study found that the consumers and merchants were mainly influenced by perceived trust and privacy, security and perceived risks, whereas the media & content promoters' adoption play a role on social influence and point-of-purchase communication. And similarly, the service providers were determined by their capacity to innovate new payment systems. For the regulators & policymakers, their role in adoption of cashless payment is determined by their ability to frame well-functioning and trustworthy payment policies leading to a conducive environment while the infrastructure focuses on providing reliable and secure physical network.

The paper contributes towards the existing literature by proposing an ecosystem which provides a holistic perspective of the cashless payment. The insights from adoption factors and the analytical ecosystem provide a comprehensive view and understanding of the crucial role each actor plays in the cashless payment ecosystem. These findings also provide some insight for policymakers to address existing adoption concerns for a successful transition towards a cashless society. Moreover, the proposed ecosystem can serve as a basis for further empirical investigation and validation by the future researchers.

This study has limitations as it only focuses on the identification of the ecosystem actors and their participation in adoption. Future study can be conducted to examine each actor in depth through empirical findings. The influencing factors for the actors can also be studied in detail by using mediating and moderating effects of independent and dependent constructs. There are also some opportunities for future studies. For instance, the issue of cashless payment adoption has been escalated due to the Covid-19 pandemic. However, its effect on the adoption is not covered in this study. Therefore, future researchers can focus on change in determinant factors or roles of the actors because of the pandemic.

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CAN ESCAPIST USE OF FACEBOOK BE TRIGGERED BY FACEBOOK PUSH NOTIFICATION?

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Abstract In this paper, the unplanned and spontaneous use of Facebook (FB) triggered by FB push notification (FPN) is explored. The concept of triggered FB use was introduced as a new type of FB use that is provoked intentionally by FB via personalized FPN. The results presented in the paper show that FPN are powerful instruments to get users back to FB. Even though FPN typically trigger users with one specific announcement, most users that react on them get immersed by the broad and persuasive offerings of FB and stay longer on the platform than it is necessary to act upon the activities promoted by the FPN. These longer stays often show escapist characteristics. Thus, FPN provide users an opportunity to escape spontaneously from the current activities and psychological states when FPN arrive. Positive gratification resulting from such spontaneous visits lays the ground for future positive reaction on FPN as users try to repeat the rewarding experience.

Keywords: facebook, push notification, escapism, social media.

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1 Introduction

Social media platforms such as Facebook (FB) offer users a rich experience through various possibilities for communication and networking as well as for consuming information from other users or numerous information sources (Young et al., 2017). These rich experiences offer a wide range of gratifications that emerged as a »... *powerful source for the satisfaction of basic psychological and social needs*« (Meier, Meltzer & Reinecke, 2018, p. 167), but also result in problematic FB addiction and overuse. One motivation for FB use that is often related to addiction is escapism (Meier, Meltzer & Reinecke, 2018; Ryan et al., 2014; Masur et al., 2014; Papacharissi & Mendelson, 2011). Escapism is in general defined as an escape from unpleasant realities via media usage (Zeuge, 2020). It is associated with avoidance oriented coping mechanism (Meier, Meltzer & Reinecke, 2018; Hoffmann et al., 2017; Ryan et al., 2014) and several authors have identified escapism as a major motivation for repetitive and addictive FB use (Meier, Meltzer & Reinecke, 2018; Young et al.; 2017; Masur et al.; 2014; Ryan, et al., 2014). Escapist FB use can furthermore negatively impact user reactions to other FB activities such as brand communication (Triantafillidou & Siomkos, 2018) or online political participation (Hoffmann et al., 2017).

Most of existing studies dedicated to the analysis of escapist use of FB consider a general use of FB as a homogeneous environment (Meier, Meltzer & Reinecke, 2018; Tang et al., 2016, Ryan et al., 2014; Masur et al., 2014). Only few studies differentiate among different types of FB usage pursued by specific groups of users or resulting from using specific FB features (Young et al., 2017; Hoffmann et al., 2017; Smock et al., 2011) Furthermore, in all studies FB use is assumed to be intentional, planned, habitual and self-initiated by users. However, FB also tries to provoke additional, unplanned use by proactively triggering users back to the platform with FB push notification (FPN) (Turel & Qahr-Saremi, 2018). While Turel & Qahri-Saremi, (2018) try to explain unplanned use of social media in general by referring to the dual system theory, triggered FB use by FPN has not been considered as a specific unplanned use in FB escapism research yet. The aim of this study is to further investigate this specific type of unplanned FB usage, focusing thereby on the following research questions:

1. Which users' personality traits are predictors of active use of FPNs?
2. Does reaction on FPNs result in triggered escapist use of FB?
3. What are the consequences of triggered escapist use of FB?

2 Theoretical Background and Hypotheses Development

2.1 Facebook Escapism

According to (Meier, Meltzer & Reinecke, 2018) escapist use of media is one of the oldest media uses and effects research that goes back to the 1950s. Escapism in general denotes an escape through media use from unpleasant realities by distracting attention from problems (Zeuge, 2020), dissatisfying life circumstances and the troubles of everyday life (Meier, Meltzer & Reinecke, 2018). It is furthermore associated with avoidance oriented coping mechanism (Meier, Meltzer & Reinecke, 2018; Hoffmann et al., 2017). For example, (Triantafillidou & Siomkos, 2018) regard escapism as part of users' FB experience resulting from brand communication and consider it to entail consumer's fantasies and imagination of living in a different world and playing alternative roles through consumption. Because of all these rewarding gratifications of escapist FB use, several authors have identified escapism as a major motivation for FB use that negativly affects users' well-being by resulting in FB addiction and overuse (Meier, Meltzer & Reinecke, 2018; Young et al.; 2017; Masur et al.; 2014; Ryan, et al., 2014). Escapist use of FB impacts also other reactions of users. For example, according to (Triantafillidou & Siomkos, 2018) escapist use of FB diminishes the reaction of users on brand communication. According to (Triantafillidou and Siomkos, 2018) »....*consumers might not be inclined to interact even in simple ways with a brand page that causes them to imagine being in a different time and place or playing an alternative role.*» Hoffman et al., 2017 discovered that consumptive FB use in escapist way, strengthens the already negative effect of consumptive FB use on online political participation.

While most of the studies cosider a general use of FB, only a few studies explore different types of FB usage seperately: For example, Smock et al. (2011) found differences between motivations for both general FB use and use of its specific features. Young et al., (2017) differentiate among active and passive FB use and discovered that passive FB use is a less effective method to escape than active FB use. (Meier, Meltzer & Reinecke, 2018) compare FB escapism and procrastination

und point out their similarities and differences. However, despite of the differences both escapist and procrastinators are prone to turn to media activities that promise a pleasurable distraction, at least in the short term (Meier, Meltzer & Reinecke, 2018). Hoffman et al., (2017) distinguish among consumptive, participatory and productive use of FB and discovered that escapistic FB use can moderate negatively online political participation.

Despite of the differences related to the FB usage types, all these studies have one common characteristic: FB use is assumed to be intentional, habitual and self-initiated by users. Triggered, i.e. unplanned FB use and its consequences on user's behaviour and well-being have not been explored in literature yet.

2.2 Facebook Push Notification (FPN)

Push notifications are short messages that are send from an application installed on a device and appear on the device's screen, when the app they originate from is not active. The goal of push notification is to proactively inform and activate users and to re-establish the connection to the originating app or companies and their offerings by triggering them back to them. To achieve this, push notification are addressing the psychological phenomenon »Fear of Missing Out (FoMO)« (Fahlman, Mejtoft & Cripps, 2018) and provke an endogeneous impulse to check the information announced by the notification immediately (Iyer & Zhing, 2022). FPN try to achieve this effect by informing users about new contributions from their friends, likes to their contributions, information or other new developents on FB that are of high personal interest to the adressed users. FPN are therefore important persuasive and motivational instruments to proactively contact users and to trigger them back to FB (see also Fogg & Iizawa, 2008). As FPN point to and request a concrete action from users the question is, if users once triggered back to the platform perform only the activity promoted by the FPN or get immersed into the offered services and use FB beyond this activity.

FPNs typically reach users while they are performing activities and everyday routines outside FB (Xu & Ding, 2014). Thus, they are often considered as interruptive and disturbing (Pielot, Church & Oliveira, 2014; Xu & Ding, 2014; Westermann, 2017) and lead to triggered, i.e., unplanned and unintended FB use. To prevent negative consequences from FPN, over recent years, FPN are provided per default in an opt-

out form and must be allowed by users explicitly. Despite of this opportunity to switch of FPN, according to Statista (2021) about 40% of users in the USA agree to receive push notification from social media and messenger even several times a day. This high interest in receiving FPN illustrates that FPN are still powerful persuasive instruments that have high potential to trigger user reactions. Of interest is who are the users that accept FPN and which personality traits result in an active use of FPN. Furthermore, as FPN are short and very focused, the question is if they can trigger escapist use of FB that goes beyond the activity announced in the notification.

2.3 Predictors of Facebook Push Notification Use and Triggered Escapism

As FPN are initiators of FB usage, it is assumed that personal predictors of FB use identified by existing research might be also predictors of active reactions on FPN. Based on existing literature the following personal trait predictors were identified as potential predictors of FB usage: need for cognition, self control, loneliness and life satisfaction (Meier, Meltzer & Reinecke, 2018; Turel & Qahri-Saremi, 2018; Ryan, et al., 2014,). Furthermore, research on push notification has also identified »usability«, i.e. the design and usefulness of push notification as predictors of their use (Iyer & Zhong, 2022; Fahlman, Mejtoft & Cripps, 2018).

Need for cognition is a personality trait reflecting the extent to which individuals are inclined towards effortful cognitive activities (Cacioppo, Petty, & Morris 1983). Individuals looking for mood regulation are attracted to an entertaining, absorbing and escapist media experience that facilitates a heuristic way of cognitive processing (Bartsch & Schneider, 2014). As FPN aim to trigger users into FB with short and easy to understand messages, it is expected that a lower need for cognition leads to a positive reaction of FPN and higher levels of triggered FB escapism. Therefore, we have formulated the following hypothesis:

H1. Need for cognition is negatively related to triggered FB escapism.

Self-control has been defined as "*the ability to override or change one's inner responses, as well as to interrupt undesired behavioral tendencies and refrain from acting on them*" (Tangney, Baumeister, & Boone, 2004, p. 275). It is seen as a cognitive behavior that tolerates short-time discomfort in order to achieve long-term goals (Myrseth & Fishbach,

2009). Individuals that can resist immediate pleasure by postponing gratifications have high self-control (Hofmann et al., 2014). Therefore, it is expected that individuals with low self-control are more prone to actively react on FPN more often even in situations when they have other things to do. Thus, it is assumed that self-control has a negative effect on a positive reaction of FPN and respectively on triggered FB escapism. Accordingly, we propose the following hypothesis:
H2. Self-control is negatively related to triggered FB escapism.

Loneliness occurs when "*a person's network of social relationships is smaller or less satisfying than the person's desires*" (Peplau & Perlman, 1979, p. 101). Previous studies have demonstrated that loneliness is a predictor of FB use (see for example the meta-analysis of Song et al., 2014). Based on the presented findings, the assumption is made that lonely individuals react upon FPN more often and might be more prone to triggered FB escapism than non-lonely individuals. According to these assumptions, the following hypothesis is proposed:

H3. Loneliness is positively related to triggered FB escapism.

Life satisfaction has been defined as the global judgment of a person's life (Pavot & Diener, 1993). Several studies confirm a negative relationship between life satisfaction as well as FB addiction and escapism (see for example Blachnio, Przepiorka & Pantic, 2016). Combining these results, we argue that escapist use of FB is used to balance real life discontent. Thus, the following is predicted:

H4. Life satisfaction is negatively related to triggered FB escapism.

Usability of FPN is considered an important success factor for an active reaction of users (Fahlman, Mejtoft & Cripps, 2018; Lyer & Zhong)**.** FPN are sent proactively to users and usually reach them, when they are occupied with other activities. The notification must tear users away from their activities and can only be successful if it is easy to comprehend, perceived as relevant, useful, and easy to react on it (see also Pielot, Church & de Oliveira, 2014; Westermann, 2017). Thus, perceived high usability and usefulness are expected to be positively related to active reaction on FPN and triggered FB escapism and result in the following hypothesis:

H5. Usability and usefulness are positively related to triggered FB escapism.

2.3 Descendants of Triggered FB Escapism

While early research on escapism contains a negative discourse about it, recent literature demonstrates that escapism also provides a way for mental relaxation and thus can release stress and improve mood (Zeuge, 2020). In fact, positive experiences and gratification resulting from escapist use of FB are a necessary prerequisite for a repititive positive reaction of FPN. In accordance with published effects of escapist FB use (i.e., Masur et al., 2014), the following implication were explored for triggered FB escapism: feeling of guilt and enjoyment as well as intrinsic need satisfaction as autonomy, competence, and relatedness (Ryan et al., 2014).

Feeling of Guilt and Enjoyment: Particularly triggered FB use might result in the feeling of guilt as it provokes unplanned FB use on the expense of other activities. Guilt operates through multiple psychological mechanisms and influences one's motivation to even stop reacting on FPN and using FB (Turel, 2015). Based on these findings, the following hypothesis are proposed:

H6. Triggered FB escapism is negatively related to feeling of guilt resulting from FB usage.

H7. Triggered FB escapism is positively related to FB enjoyment.

Eudaimonic need satisfaction: According to existing literature FB can stimulate not only hedonic experiences but also rewarding social and cognitive experiences (Zeuge, 2020). Self-determination theory (Ryan & Deci, 2000) – which is a well-established approach within the eudaimonic research perspective – suggests that individuals strive for the fulfillment of the following intrinsic needs: 1) the need for autonomy, described as a feeling of volition and freedom of choice (Ryan & Deci, 2006). An individual senses autonomy when he/she can think and act freely from external constraints. 2) The need for competence, referring to feelings of efficiency and capability satisfied through ideal challenges and positive feedback (Ryan, 1995). 3) The need for relatedness and close social relationships. This need is shaped by the desire of belonging, closeness and intimacy with others (Ryan & Deci, 2000). The fulfillment of these three needs can positively influence psychological well-being (Reis et al., 2000; Reinecke, 2012). Regarding the abovementioned considerations, the following hypothesis are proposed:

H8. Triggered FB escapism is positively related to autonomy.

H9. Triggered FB escapism is positively related to competence.

H10. Triggered FB escapism is positively related to relatedness.

Duration of Stay: As mentioned above, we hypothesize that FPN can initiate longer stays, if the user reacting on a notification gets immersed onto the platform and consumes available content and services in an escapist way.

H11. Triggered FB escapism is positively related to a duration of stay of 0 – 10 minutes.

H12. Triggered FB escapism is positively related to a duration of stay of 10 – 20 minutes.

H13. Triggered FB escapism is positively related to a duration of stay of 20 – 30 minutes.

The resulting research model is summarized in Figure 1:

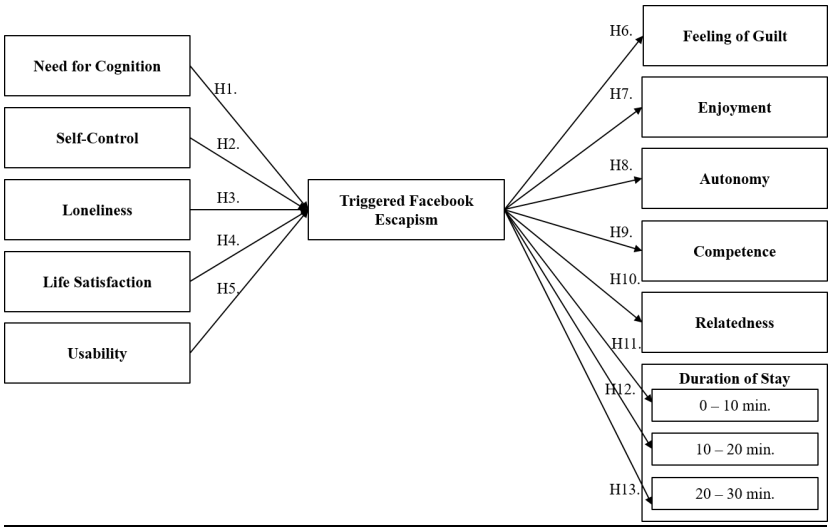


Figure 1: Research Model

3 Method

In order to test the developed hypotheses and answer the research questions, 442 undergraduate and graduate students from a large university in the USA participated in an online questionnaire. Students enrolled in business school courses participated in the survey as part of a research lab-seminar (respondent rate = 100%). Both genders were equally represented in the study group (54% females) Participants were between 18 and 35 years old. A majority of the participants (36%) were 20 years old. Only 3% of participants held a Master's or Doctoral degree, while undergraduate students represented 69% of those surveyed. Overall, 85% of respondents indicated themselves as students. 403 participants (93.3%) have a FB profile. 106 (26.8%) participants use FB daily and 145 (36.6%) several times a day. Most of the participants, 305 (69%) stay on FB up to one hour and 237 (59.1%) allow FPN.

Measurement model: Triggered FB escapism was measured with six items that were developed in close reference to existing operationalizations (e.g. Katz et al., 1973; Meier et al., 2016; Papacharissi & Mendelson, 2011): forgetting worries and problems of everyday life, escaping from reality, distraction and mood management such as relaxation and unwind. The duration of the triggered visit was measured as being 0 – 10, 10 – 20, and 20 – 30 minutes. The predictor and descendants of triggered FB escapism were measured based on scales proposed by literature mentioned in the theoretical section. The complete measurement model contains 11 latent constructs and 46 items.

Before testing the structural model, we exploited the measurement model, as suggested by Gerbing and Anderson (1988). Hence, a confirmatory factor analysis was implemented to test for uni-dimensionality and scale reliability on the construct level. Cronbach's alpha (α), composite reliability (C.R.) and average variance extracted (AVE) were calculated. This approach caused the removal of one item from the need of cognition scale, due to the induced decrease of the reliability coefficients. After this regulation, the Cronbach's alpha values ranged from to 0.726 to 0.976, exceeding the recommended 0.7 threshold (Blanz, 2015) and indicating acceptable internal and composite reliability. Assessing convergent and discriminant validity provided acceptable evidence for construct validity (Fornell & Larcker, 1981). CR values ranged from 0.752 to 0.972, exceeding the recommended 0.7 threshold (Raykov, 1997) and indicating good construct reliability (Fornell &

Larcker, 1981). AVE values for all scales exceeded the recommend threshold of 0.5 (Hair et al., 1998) indicating acceptable convergent validity. The means ranged from 1.38 and 4.27 and the standard deviation amounts to 0.72 and 1.18. Regarding discriminant validity, the AVE value for each pair of constructs was compared with the square of the correlation between the two constructs (Fornell & Larcker, 1981). The Fornell-Larcker-Criterion fulfills the necessary requirements and shows the discriminant validity of the model (Fornell & Larcker, 1981).

Results: The overall model shows strong confirmation for most of the hypotheses as ten of thirteen hypothesized and estimated paths are significant ($p \leq 0.05$) (see Table 1). Usability has the strongest effect on FPN and triggered FB escapism ($\beta=0.29$, $p < 0.001$), followed by self-control ($\beta =-0.19$, $p < 0.01$). Thus, users are more likely to respond to FPN when the usability of the notification is high, and their self-control is low. There is no significant direct impact from the remaining three independent variables. Regarding the effects of triggered FB escapism on user experience, the results show that all relationships are (highly) significant (see Table 1). This confirms the results of existing research (i.e., Shi et al. (2010) or Langrial (2015)). Moreover, triggered FB escapism is strongly negatively linked to the feeling of guilt ($\beta=-0.46$, $p<0.001$). Thus, FPNs can initiate positive entertainment feelings without causing a negative feeling afterwards.

Another interesting finding for the impact of triggered FB escapism is that a shorter time of stay (0–10 minutes) is strongly negatively linked ($\beta=-0.31$, $p<0.001$) in contrast to a longer duration of stay such as 10–20 minutes ($\beta=0.26$, $p<0.001$) and 20–30 minutes ($\beta=0.12$, $p<0.05$).

Table 1:– Parameter Estimates and Hypothesis Testing

Relationship	**Std. Estimate (t-value)**	**Result**
H1. Need for cognition is negatively related to PN and Triggered Escapism	0.018 (0.300)	not supported
H2. Self-control is negatively related to PN and Triggered Escapism	-0.192 (-2.610)**	supported
H3. Loneliness is positively related to PN and triggered Escapism	0.070 (0.831)	not supported
H4. Life satisfaction is negatively related to PN and Triggered Escapism	-0.002 (-0.020)	not supported

H5. Usability is positively related to PN and Triggered Escapism	0.288 (3.818)***	supported
H6. Triggered Escapism is negatively related to Feeling of Guilt	-0.457 (-9.704)***	supported
H7. Triggered Escapism is positively related to Enjoyment	0.266 (4.414)***	supported
H8. Triggered Escapism is positively related to Autonomy	0.237 (2.993)**	supported
H9. Triggered Escapism is positively related to Competence	0.345 (5.328)***	supported
H10. Triggered Escapism is positively related to Relatedness	0.393 (7.014)***	supported
H11. Triggered Escapism is positively related to Duration of Stay (0-10 min.)	-0.314 (-5.687)***	supported
H12. Triggered Escapism is positively related to Duration of Stay (10-20 min.)	0.259 (4.356)***	supported
H13. Triggered Escapism is positively related to Duration of Stay (20-30 min.)	0.125 (2.233)*	supported

** $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$*

4 Discussion

In this paper, the unplanned and spontaneous use of FB triggered by FPN is explored. The concept of triggered FB use was introduced as a new type of FB usage that is provoked intentionally by FB with personal FPN. The findings resulting from the research presented in the paper show that FPN are powerful instruments to get users back to the platform. Even though FPN typically trigger users with one specific announcement (i.e., *you have a new like to your post*), most users that react on them get immersed by the broad and persuasive offerings of FB and stay longer on the platform than it is necessary to act upon the activities promoted by the FPN. These longer stays often have escapist characteristics. Thus, FPN provide users an opportunity to escape spontaneously from the current activities and psychological states when FPN arrive. With other words, on many occasions FPN might be a welcomed destruction of ongoing activities. Positive gratification resulting from such spontaneous visits lays the ground for future positive reactions on FPN as users try to repeat the rewarding experience.

With respect to the first research question the research results revealed that antecedents with significant positive impact on FPN reaction and initiation of triggered FB escapism are low self-control and high-perceived usability of the notification. This are typically also users that do not take advantage of the opportunity to switch FPN of. The fact that 59.1% of the survey participants and according to Statista (2021) 40% of USA users allow FPN shows that the opportunity to self-regulate FPN does not protect users in sufficient manner yet. Further measures are necessary to increase the protection for users. The finding points also to the importance of the appropriate design of FPN. The high proportion of users that react on FPN shows that platforms have learned how to design push notification in highly persuasive way.

Second, we analyzed the potential triggering of FB escapism through FPN (2nd research question). Our empirical results show that FPN can result in triggered FB escapism. Users do not consume only the specific service promoted by the FPN, but once they enter the platform, they stay among 10 – 20 minutes and even longer. Thus, FPN favor and provoke addictive overuse of FB.

Finally, the consequences of triggered FB escapism were assessed. The most surprising results are the positive user gratification and experiences resulting from triggered FB escapism. Even though FPN reach users unexpectedly, when they might be busy with other obligations, reacting on them seems not to provoke feeling of guilt. This might be explained with the compensation from the rewarding experiences in terms of autonomy, competence and relatedness.

Overall, it can be concluded that FPN are successful trigger, or in terms of (Eyal, 2014) hooks that can initiate a persuasive "Hooked" cycle.

4 Conslusion, Limitations and Further Research

With the above results, the study presented in this paper provides the following scientific contributions:

- Analysis of ascendant and descendant of unplanned FB use provoked by FPN, that have not been considered in research yet. This study goes beyond

studies that consider unplanned social media use in general (see for example Turel & Qahr-Saremi, 2018)

- Introduction of the concept of triggered FB escapism. Compared to escapism in classical media, the ability of FB to trigger escapism is a unique feature of interactive media. Classical media have no interactive connection to their audiences and cannot proactively trigger media use.

The major practical contribution of the study is the insight that current practices that allows users to explicitly opt-in for FPN are not sufficiently protective. Further, ethical designs of FPN are required. One option might be to providing a summary of FPNs only at specific timepoints and frequencies defined by the users.

Despite of the scientific and practical contribution, the study has also several limitations: The survey participants were students and are therefore representing only a subgroup of the general user population of FB. Since other factors, e.g., flexibility in daily time schedule (students are more flexible than employees) or familiarity with media usage (older vs. younger populations) can influence the responsiveness to FPN other target groups should be investigated. Also push notifications differ between different platforms, making it necessary to investigate the influence of push notifications for different platforms individually. The survey also concentrated on US students. Due to cultural differences, results in other countries might be different. Since excessive media use has a negative impact on individuals additional research is needed on how FPN could be created in a more ethical way.

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How to Use Data to Increase Bike Use by Travelers

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Abstract The Government of the Netherlands wants to be energy neutral by 2050 (Rijksoverheid, sd). A transition towards non-fossil energy sources also affects transport, which is one of the industries significantly contributing to CO2 emission (Centraal Bureau Statistiek, 2019). Road authorities at municipalities and provinces want a shift from fossil fuel-consuming to zero emission transport choices by their inhabitants. For this the Province of Utrecht has data available. However, they struggle how to deploy data to positively influence inhabitants' mobility behavior. A problem analysis scoped the research towards data to stimulate cycling. Three interviews, desk research and a survey revealed the gap between the province's current data-item approach that is infrastructure oriented and the required approach that adopts traveler's personas to successfully stimulate cycling. For this more precisely defined captured data is needed and the focus should shift from already motivated cyclists to non-cyclers.

Keywords: zero emission, mobility behavior, transport choice, data driven mobility.

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1 Introduction

The European Government's sustainability goal to reach zero-emission by 2050 provided the trigger for this research (Rijksoverheid, n.d.). The Province of Utrecht (hence province) exists of twenty-six municipalities that together present an estimated number of 1,36 million inhabitants (Provincie Utrecht, 2019). Each municipality and the province itself perform the role of road authority. The province questioned their utilization of available mobility data as a mean to change inhabitants' behavior about their day-to-day transportation modality choices. To date, the use of available data from different external data providers has not delivered the expected results. Currently, the Netherlands hosts 22.8 million bicycles with an average of 1.3 bicycles per citizen (Fietsersbond, 2020). With annual sales reaching between the 900,000 to 1,400,000 bikes (Railvereniging, 2021) of which 50% are currently e-bikes the province wants to turn these available assets into 'zero emission' transport options. Analyzing all twenty-six mobility plans of the municipalities showed 38% the word 'bicycle' and 32% the word 'car'. All plans showed a strong interest in *how to replace the car by bike trips*. This narrowed the research scope of this study down to the bicycle as transport modality. Although the well-developed cycling infrastructure in the Netherlands helped reducing car trips in general, the road authorities want to further increase transport by bicycle. For this, available bicycle-data need to become indicators that positively influence mobility behavior. Therefore, the research question formulated is: *"Which data leads to specific information that helps road authorities to nudge travelers' mobility choice towards bicycle use?"* This main question led to three sub-questions:

1. What factors positively stimulate the traveler's decision to use a bicycle?
2. Which factors related to stimulating bicycle use can the province obtain from the twelve bicycle-data-items?
3. Which differences form the gap between the twelve bicycle-data-items of the province and that of the travelers' decision factors found at sub-question one?

This paper presents a theoretical background followed by the research approach. Subsequently, the research results, conclusions and recommendations to the province follow. The paper ends with limitations and a discussion.

2 Theoretical backgrounds

In 2005 the EU started to address sustainable mobility in the thematic strategy on urban environment (EC, 2005). In 2009, this grew into the Sustainable Urban Mobility Planning (SUMP) approach and within four years a guideline for use by municipalities of the EU countries was added (EC, 2009; EC, 2013). Different studies show that the success of adopting SUMP in EU countries depended on municipalities goals and vision that often miss climate change and social equity. However, the SUMP itself missed specific guidance and a common framework for equity evaluation to offer equal assessments among cities (Urban Mobility Observatory, 2022) as well as adequate smart climate targets that are necessary to achieve the sustainable goals (Mozos-Blanco et al., 2018). The goal of zero emission increases the importance of available mobility data at a local level, e.g., presenting numbers and volumes of types of mobilities used as well as the motivation for a mobility choice. Therefore, regardless SUMP, the mobility transition requires a data driven approach as picked up by the provence.

2.1 Literature review

Prior to understanding the data driven mobility transition challenge of the province this study first defined the terms: *Mobility and behavior, City based transport,* and *Data driven mobility*. Using Google Scholar and HUGO (the university's search engine) resulted in 390,459 hits. Adding word combinations, trend information on travelers, commuters, and bicycle usage and adopting the snowball effect on useful references resulted in thirty-two useful articles.

2.1.1 Mobility

This study defines mobility as the empowerment of how people or objects can move (Hazelhorst, Metz, & Schreuders, 2005). As understood from SUMP, due to climate change Mobility needs proper planning. A mobility plan supports the traffic flow and helps to manage mobility (Frank Wefering, 2014). For social relevance municipalities' traffic policy should centralize the user and focus on explicit intra-municipality knowledge sharing (Klieverik & Tutert, 2011). Therefore, for this research a mobility plan for attracting cyclist must focus on the users of the municipality's cycle lane infrastructure, whilst the plan is also designed to manage

traffic flows from e.g., safety perspective. Our daily usage of means of transport influences our commuting choices (Zeiske, Werff, & Steg, 2021). Sustainable commuting needs sustainable modality choices and due to Covid-19 the bicycle proved to be safe, sustainable, and efficient (Fenu, 2021). Travelers can be inhabitants commuting between home and work, or persons travelling with another objective. This study concerns travelers, regardless their home location and travel objective. They travel in the province and/or cross its municipalities. This study leaves out travelers' behavior of being the e.g., conscious, forced, pro-health, or lifestyle cyclists (Biernat, 2018) due to the province missing such behavior data.

2.1.3 City based transport

The European committee asked European cities to adopt sustainable transport facilities and using eight sustainable principles for this (Urban Mobility Observatory, 2021): the plan must be for the entire functional city; have a long-term vision; cooperates across institutional boundaries; addresses all transport modes in an integrated manner; with involvement of citizens and stakeholders; includes monitoring and evaluation in its design; assesses current and future performance; and assures quality. Adaptation of sustainability also requires focus on *social equity* in supporting all inhabitants with their transport needs (Arsenio, Martens & di Ciommo, 2016).

Cycling as modality can be integrated with other zero emission modalities. It requires bicycle facilities as general term for infrastructure and services to encourage bicycle usage e.g., bicycle parking, storage possibilities, and special bicycle lanes, lighting, speed ways, etc. (Connecticut ATP, 2018). Safety and parking are important facilities influencing cycling behavior of citizens.

The transformation towards sustainable road transportation results in new business models e.g., sharing modalities (Sarasini & Linder, 2018). Flexible rental bicycles at train stations did reduce car use and increased train trips, and bicycle use for non-recurrent trips (Martens, 2020). However, these improvements are insufficient to reach the 2050 sustainability goals. Personal attitudes and preferences, residence, safety, the difference between destinations, and the time it takes to travel between these determine mobility behavior (Macharis, 2018) and therefore the adoption of cycling.

2.1.4 Data driven mobility

Zhang et al. (2021) show the complexity of using data to support travelling behavior in an organized city with various parts interacting with each other where achieving sustainable urban transportation and a resilient society are trends. Therefore the road authorities require data to guide the complex transition. With data driven mobility as viewpoint, this study's main subject is data and data-items.

3 Research approach

To answer the research question an evaluative, deductive research approach using multiple research methods is followed. Starting with desk research, a survey (quantitative research) and interviews (qualitative research) followed. Triangulation was performed managing the desk research data collection as primary, and the survey and interview data as secondary data.

3.1 Research model

A gap analysis determined the difference between the data required to nudge citizens to move from their car to a bicycle as means of transportation (SOLL situation) versus the data available (IST situation) at the province. The difference found is object to improvements to achieve the desired result by eliminating the gap (Vries, 2018). The SOLL situation as answer to the first sub-question was found through the 'conceptual state analysis' (CSA), because it offers the ability to develop an unbiased opinion without effects of investment in time or money in the past. The CSA process entailed: *defining* by deploying desk research, *inferring* by analysis, exploring via brainstorm sessions with the province data team and a survey, *reasoning about* via in-depth interviews, and *revising* conceptual attributes of a new situation and their possible values via evaluations (Mordecai & Crawlet, 2021). Next, the IST (second sub-question) was described by deploying desk research and in-depth interviews with the province data team. Desk research and in-dept interviews helped finding the gap (third sub-question).

3.2 Research methods

Through desk research the scope of the research narrowed down to the bicycle as means of transportation by travelers and provided insights in required data to stimulate cycling. The literature found formed the bases for the brainstorm sessions, the interviews and survey questions. The province data team supported to create a list of nineteen questions. Family, friends, relatives, and social media followers of the research team, including the members of the province formed the survey target group. They all received the survey via a Google Forms page. During the last two weeks of December 2021 the survey was placed online (LinkedIn, Instagram and WhatsApp). This resulted in 190 fully answered surveys out of 220 reactions. Sub-questions one and three used the outcome of the survey to validate the answers found through desk research.

Three in-depth interviews validated the reliability of the desk research findings. The interviewee were three different persons associated with bike use: the road authority of the Municipalities of Utrecht and of Amersfoort, and the 'bicycle mayor' of Utrecht. The data team of the province organized the interviews as digital meetings via Microsoft Teams. The interview questions were based on desk research and consultations with the research supervisor and were evaluated with the province data team. The interviews helped validating the desk research and the descriptions of the data-items.

4 Results

This section presents the findings in relation to the three sub-questions.

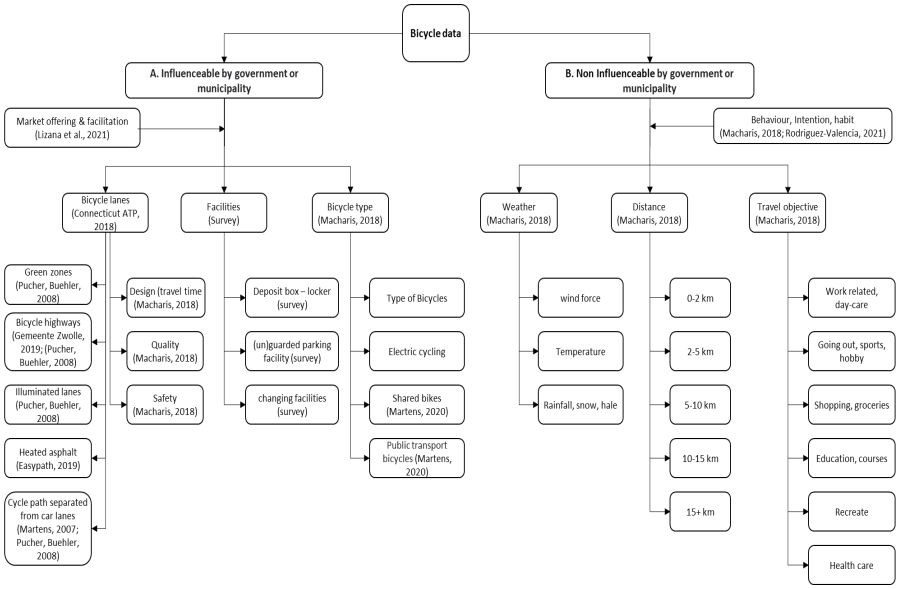
4.1 Factors that affect the choice to cycle

Based on desk research, brainstorm sessions, interviews, and subsequent analyses a framework of dimensions and underlying variables that influence the behavior of cyclists is developed (see Figure 1). Data regarding cycling has two dimensions:

(A) data that can be influenceable by the province and (B) data that cannot. Both have underlying dimensions of importance. Due to being influenceable this study focusses on Dimension (A) and its constructs: bicycle lanes, facilities, and the type

of bicycles. Next to behavior, these three constructs affect the transport modality choice of travelers. Consequently, the attractiveness of bicycle lanes depends on their quality and safety (Martens, 2007; ANWB, 2020). To improve safety on bicycle lanes solutions are available, such as bicycle highways with limited intersections and traffic lights (Gemeente Zwolle, 2019); heated bicycle lanes to prevent from freezing and improve safety while cycling in winter (Easypath, 2019); implementing LED lightning on bicycle lanes to improve safety during darkness with lights that react to movement and turn on when a cyclist passes by to help motorists notice the cyclists (Provincie Utrecht (2019).

Figure 1: Dimensions, variables and factors affecting cycling behavior



Facilities include amenities and accessories that cyclists require to make their travel more comfortable. A survey of January 2021 (BIM University of Applied Sciences Utrecht, 2021) shows that more than 50% of travelers find 'facilities' an essential decision factor for cycling. The survey of January 2022 zooms in at types of facilities at the arrival location that may influence the decision to go by bike. These are Secured bicycle parking 68.5%; Unsecured bicycle parking 35.5%; Bicycle province mp12.7%; Changing facilities 7.6%; Lockers 6.1%; Shower 5.6%. The secured bicycle parking makes a true difference in the modality choice.

4.2 Bicycle data province

The twelve available data-items and their priority according to the province does not fit the priority seen from a cyclist. The province rates data-items: *Bicycle parking (capacity and occupation); Travel behavior and motives; Insight demands and experiences bicycle;* and *Personal characteristics cyclist* as 'Low important' whilst desk research identifies these items as required to influence cycling. 'Medium' ranked data-items are: *Digital main grid; Type of bicycle (ownership and usage);* and *Supply and availability bike sharing* mainly because it is relatively easy to get these data-items. 'High' ranked are *Origin-Destination pattern, routes, speeds; Information bicycle infra characteristics; Use of cycling network;* and *Road safety*. This ranking is understandable, due to the influence the province has on these data-items.

Like *Travel behavior and motives,* it is important to identify the needs and the persona of cyclists because not every population group is equally willing to take the bicycle (Bakker, 2021; CBS, 2019). Also, the survey proved that people who cycle more, reduce their car movements. Understanding which groups can successfully be stimulated in behavior, will result in an increase in car replacements. However, the province priorities are with data related to infrastructure and traffic flow. Interviews show that opinions on the data-items vary from 'too much data, which leads to complexity' (Tiemens, 2021) to "there is never enough data, if you know what to do with it" (Hepp, 2021). Analyzing the twelve data-items shows ambiguousness and overlap e.g.: '*Use of cycling network*' and '*Origin-Destination pattern, routes, speeds*' both include the same routes, which questions the data structuring method (Hepp, 2021).

4.3 Data item similarities and differences

Table 1 shows similarities and differences in bicycle data between the SOLL (research) and the IST (currently available). The white cells in the table present a direct link between the IST and the SOLL which means that the described data-items of the province corresponded exactly with that of desk research. Next, the black cells present that a direct link is missing. '*Facilities'* and '*Weather*' are least noticed by the province as important factors that help to increase the number of active cyclers because of the impact these factors have on bicycle usage (Leunga & Linh Le, 2019). The province's focus is on infrastructure and facilities. The infrastructure is for 19.8% of the survey respondents not a trigger, because they

always cycle; 10% prefers lighted lanes at dark; and 16% likes separated lanes from cars.

Table 1: GAP between bicycle data model of researchers SOLL and province IST

Research based cycling construct: The 12 Bicycle modality data-items:	*Bicycle lanes*	*Facilities*	*Bicycle type*	*Weather*	*Distance*	*Travel motive*	*No. missing*
Using the bike network		■	■	■		■	4
Origin-Destination (OD) pattern, routes, speed		■	■	■			3
Digital basic network		■	■	■		■	4
Information Bike Infrastructure characteristics		■		■	■	■	4
Bicycle parking (capacity and occupation)	■		■	■	■	■	**5**
Translocation behavior and motives	■	■	■	■			4
Insight in wishes and experiences cyclist			■		■		2
Flow optimization traffic crossings		■	■	■	■	■	**5**
Bike sharing offering and availability	■	■		■	■	■	**5**
Personal characteristics cyclist	■	■		■			3
Bicycle type (owned and used)	■	■		■			3
Traffic safety			■		■	■	3
No. missing	5	**9**	8	**10**	6	7	

5 Conclusion

In this section we discuss the findings of each sub-question to subsequently provide an overall conclusion.

5.1 Sub-question 1

The first sub-question to answer is: *What factors positively stimulate the traveler's decision to use a bicycle?* As figure 1 shows there are 29 factors that influence the cyclist decision. With the interconnection at the level of the six constructs this data model

shows options to discover how to motivate cyclists to increase their numbers of trips by bike. For example, the fact that it is freezing in the Netherlands is uninfluenceable (variable weather), however, slippery frozen bicycle lanes can be improved by equipping these lanes with heating elements (variable bicycle lanes). The same factors will also improve the motivation of non-cyclers to support zero emission travelling and start cycling.

5.2 Sub-question 2

The second sub-question to answer is: *Which factors related to stimulating bicycle use can the province obtain from the twelve bicycle-data-items?* The twelve data-items used by the province are available from external sources and miss a detailed description of what each item presents. The province has no influence in how these data-items presents themselves and how and why (purpose) their partners capture the data. Therefore, the dataset the province uses, can be seen as an ad random set that exists through coincidence. Consequently, the users misinterpreted the data-items in practice. Also, among the twelve data-items overlap appears: The item *(OD) pattern, routes, speed* coincides with the item *Using the bike network*. Also, *Digital basic network* partly overlaps with *Information Bike Infrastructure characteristics*. Additionally, it is difficult to determine which data-item includes data about bicycles and cycling. The province ranked the four most valuable data-items found through this study as 'low' priority, whilst the survey showed a 68% on parking as motivator. Therefore, the province misses capturing and understanding the opinions and desires of the cyclist to nudge more cycling.

5.3 Sub-question 3

The third sub-question to answer is: Which differences form the gap between the twelve bicycle-data-items of the province and that of the travelers' decision factors found at sub-question one? The gap analysis shows that the IST has little emphasis on the constructs 'Weather' and 'Facilities' regardless the fact that both do have a major impact on cycling behavior and therefore directly impact the travelers' mobility choice (eleven out of the twelve data-items focus on the cyclist). Data item 2 Travel behavior and motives (Table 1) has a broader focus then the cyclist only. Through this item interest in defining persona's is possible. So far, the province

provided her service around the available data-items, instead of firstly defining data driven mobility management as service to the road authorities.

5.4 Overall conclusion

The most important conclusions concern the viewpoint by the province and the unstructured data-item approach. The current focus is what the cyclist does (once the cycler is on the road). However, to stimulate more inhabitants to become frequent cyclers demands focus on factors that influence bicycle use and the needs of the non-cyclists. The data-items *What distance the cyclist travels* and *What routes they use to reach their destination* indicate the strong focus on infrastructure. Therefore, the province misses stimulating non-cyclers. Unfortunately, the focus on the twelve data-items only, also limits the province in utilizing a broader range of information sources.

6 Recommendation, limitations and discussion

The province should upgrade the four data-items that link directly to the cyclist with grade 'high' to nudge travelers to (more) cycling and to improve the data-items description including their source and method of capturing. Only then the province can analyze data-items regarding their value as cycling motivating factor for their road authorities. Also, the province should adopt a data driven mobility management approach as a service. Adopting the newest tools of SUMP will be useful. On data itself a structured approach in which the cyclist is present as a persona, will help better understand the data-items needed.

The survey result is indicative. Next to a limited number the division of respondents misses accuracy because handing the survey out to friends and family members of the researchers. As a result, the respondents do not present the age, profession, and travel objective build-up of the Province of Utrecht.

Follow-up research will define and validate personas to better understand the (non-)cyclist; to adopt differences at city levels matter (Mitra et al., 2021); and to add findings from all twenty-six road authorities. Extension in developing the motivation factors found at Figure 1 will deepen the insights in how to reduce more emission by having the car replaced by bike trips.

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A Comparative Study of Machine Learning Models for Sentiment Analysis: Customer Reviews of E-Commerce Platforms

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Abstract Understanding customers' preferences can be vital for companies to improve customer satisfaction. Reviews of products and services written by customers and published on various online platforms offer tremendous potential to gain important insights about customers' opinions. Sentiment classification with various machine learning models has been of great interest to academia and practice for a while, however, the emergence of language transformer models brings forth new avenues of research. In this article, we compare the performance of traditional machine learning models and recently introduced transformer-based techniques on a dataset of customer reviews published on the Trustpilot platform. We found that transformer-based models outperform traditional models, and one can achieve over 98% accuracy. The best performing model shows the same excellent performance independently of the store considered. We also illustrate why it can be sometimes more reliable to use the sentiment polarity assigned by the machine learning model, rather than a numeric rating that is provided by the customer.

Keywords: customer reviews, sentiment analysis, RoBERTa, machine learning

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1 Introduction

With the rapid advancement of Internet technology in recent years, online shopping has become a popular means for people to buy and consume goods. In particular, e-commerce sectors, which have thrived amid the COVID-19 issue, have experienced extraordinary and unexpected development. These trends increase the already high importance for organizations to understand and optimize the way customers interact with online e-commerce platforms in order to increase customer satisfaction. An increasingly utilized source of information that organizations can make use of is online reviews. While customer reviews can provide valuable information related to products and services, the sheer quantity of these reviews makes it infeasible and impractical for manual inspection. Companies are required to increasingly make use of advanced natural language processing (NLP) tools and machine learning techniques to understand their customers better and stay competitive in the market (Jagdale et al. 2019).

The most valuable piece of information in reviews, additionally to a numeric rating, is contained in the free-form comments on the product or service. Consumer evaluations typically include useful information regarding product quality as well as helpful recommendations. However, it is not a straightforward task to extract the relevant information. Various tools of NLP are now increasingly used in understanding customer satisfaction, such as sentiment analysis (Sun et al., 2019), topic modeling (Piris & Gay, 2021), text summarization (Tsai et al., 2020), and automated translation (Gangual & Mamidi, 2018).

By understanding the emotional polarity of messages with sentiment analysis, companies can gain a detailed understanding of customers, and identify what products and services are perceived negatively or positively by customers and why. The company needs to be able to constructively evaluate good and negative feedback and make better judgments based on the needs of customers. In this article, our main focus is to *compare the classification performance of traditional machine learning techniques and a more recent invention, the RoBERTA model* in sentiment evaluation of online reviews (Liu et al., 2019). By identifying the best performing model, we can aid decision makers in understanding customer's prerences better, and in turn improve the offered services. To address this research problem, we collected 3500 user reviews from the online platform Trustpilot, which hosts reviews to help consumers in

online shopping. The messages were randomly selected and manually annotated by the authors of this article using the polarities 'positive', 'negative', and 'mixed'. After data preprocessing, several machine learning models were tested and the best performing models were identified. The models utilized include Support Vector Machines, Naïve Bayes, BERT, and RoBERTa.

The rest of the article is structured as follows. In Section 2, a brief literature review is presented to discuss different approaches to sentiment analysis, and specifically how they have been applied to analyze customer reviews. The research methodology, data collection, and processing are presented in Section 3. Section 4 contains the main results: we interpret the findings and compare them to previous literature. Finally, we present some concluding remarks, limitations, and future research directions in Section 5.

2 Sentiment analysis of customer reviews

The goal of sentiment analysis is to determine how sentiments are represented in texts and whether the expressions suggest positive or negative attitudes about the subject (Nasukawa & Jeonghee, 2003). The most fundamental application of sentiment analysis is to gather people's opinions, in particular in the form of customer reviews. Many business decisions are influenced by such viewpoints (Rajput, 2020). Formally, as presented by Zeng et al. 2019, sentiment analysis can be defined as "the process of automatically analyzing the subjective commentary text with the customer's emotional color and deriving the customer's emotional tendency". In the following, we summarize the different approaches focusing on the different families of techniques used in sentiment analysis.

Based on the technique used to perform sentiment analysis, one can typically make a distinction between (i) lexicon-based and (ii) machine learning approaches. In lexicon-based approaches, an existing dictionary is utilized, which contains a sentiment polarity/intensity for words and expressions; then the sentiment is determined by the majority of polarities in the text. Additionally, to general dictionaries such as the Harvard GI, there exist some domain-specific dictionaries available, e.g. the Financial Polarity Lexicon in finance (Malo et al., 2014). While we can identify approaches to construct a domain-specific dictionary for user reviews, such as the one presented by Han et al. (2018), in this domain, generic dictionaries

are mainly used to evaluate sentiments, with the most frequently used one being the SentiWordNet (Baccianella et al., 2010). Han et al. (2018a) present a good example of utilizing lexicon-based sentiment analysis using the text of reviews from the online commerce site Amazon. By accounting for the possibility of bias, the authors complement the use of lexicons with a weighted processing strategy and found the results to be superior. In the model, optimized weights combining positive and negative score of a review are included as "many methods present more positive values than negative values, especially the lexicon-based method".

Lexicon-based approaches can offer a good baseline solution, as in most cases typically 70% sentiment classification accuracy is achievable. In recent times, a different stream of sentiment analysis techniques has become dominant: machine-learning based approaches. Developments from the last decade are numerous in this domain, with the first important being the new approaches to improve on traditional text representation methodologies (such as term frequency-inverse document frequency) with word, and later sentence encoders, including most importantly Word2Vec and Doc2Vec. These word/sentence encoders assign comparable vectors to words/sentences that appear in the same context because they are semantically similar. As an example, Shuai et al. (2018) applied Doc2vec and various machine learning algorithms such as Support Vector Machine, Logistic Regression, and Naïve Bayes on 11600 hotel reviews. They found that the best performance (80% precision and 88% recall) can be achieved by combining Doc2Vec with Support Vector Machines.

In order to further improve word and sentence embeddings, language transformer models were introduced (Vaswani et al., 2017) with the idea of creating different embeddings for a word instead of a fixed one, to incorporate information on different contexts. Making use of encoder and decoder, an extensive, unsupervised pre-training and fine-tuning on labeled data, transformers can be used to solve a variety of text classification problems, including sentiment classification. One of the first transformer models, and arguably the most influential one, is BERT (Bidirectional Encoder Representations from Transformers), introduced by Devlin et al. (2019). The BERT approach has two stages: pre-training and fine-tuning. The pre-training stage includes two unsupervised tasks: a masked language model and sentence prediction. Through supervised learning, BERT's pre-trained language model can be fine-tuned for specific purposes. In the last few years, several

extensions of BERT have been introduced, both general, such as RoBERTa, and domain-specific, such as FinBERT. These, and other transformer models (e.g. XLNet), have been proven to outperform traditional NLP models, in particular in sentiment analysis problems.

At the same time, we can only identify a handful of articles applying language transformers to sentiment classification. Xie et al. (2020) performed sentiment analysis of Chinese e-commerce reviews. They perform aspect-based analysis using automated sequence annotation. The authors extend the basic version of RoBERTa and find that it can achieve up to 90% accuracy. Li et al. (2021) develop a novel sentiment analysis model for Chinese stock reviews based on BERT. The authors find that the best performance (92% accuracy) is obtained by adding a linear layer to the BERT outputs and using a fully connected layer for prediction. In this article, motivated by the findings of the presented literature review, we aim to present a comparison of various traditional and deep learning-based machine learning models for sentiment classification, by making use of a newly annotated dataset in the context of e-commerce. Liao et al. (2021) propose a multi-task aspect-category sentiment analysis model based on RoBERTa. The authors use the RoBERTa based on deep bidirectional Transformer to extract features from both text and aspect tokens, and the cross-attention method to instruct the model to focus on the features most relevant to the given aspect category, treating each aspect category as a subtask.

3 Methodology

In this section, we will present the NLP-based methodology of sentiment analysis. Our main goal is to identify the best-performing models of sentiment classification based on customers' online reviews. As shown in Figure 1, we have applied five steps to achieve our research objective. In this section, we discuss data collection, annotation, preprocessing, and present the machine learning models used for sentiment classification.

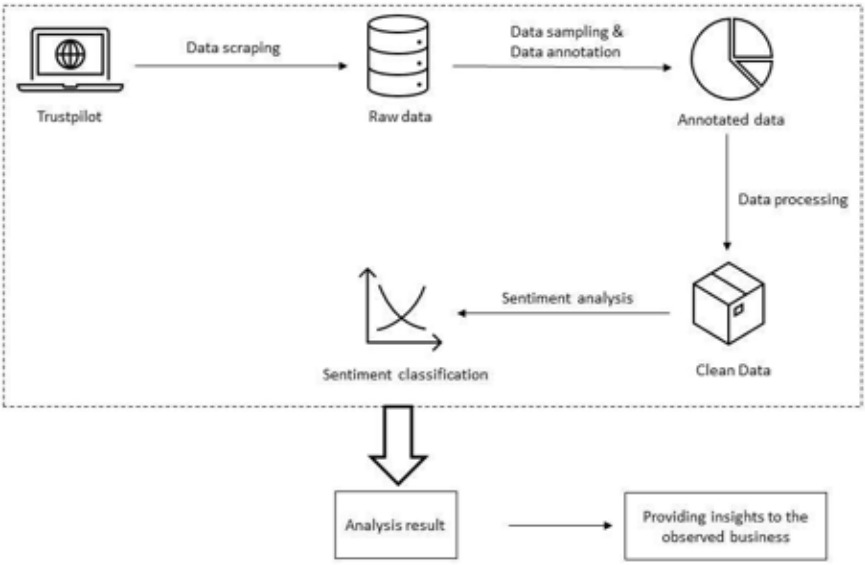


Figure 1: The stages of the research process

3.1 Data collection and processing

We aimed to collect data from one of the largest customer review sites, Trustpilot[1]. The data collection focused on reviews of online stores, written in English. After a preliminary check of available reviews, we opted to collect data from five e-commerce platforms, written in the time period between 2012 and 2021, with most of the comments from 2021. The total number of collected reviews is approx. 12,000. The stores included in the analysis are the following: Zalando (35% of data), Wish (24%), Sheinside (19%), Boozt (17%), and Nelly (5%). To complement the text of the reviews, the following additional information was collected: header of the review, numeric rating (range 1-5), location of the user, date of the reviews, total number of reviews previously written by the user.

In order to perform sentiment analysis, a polarity value needs to be assigned to each review. As highlighted in the literature review, while there exist lexicons for customer reviews, the results utilizing them are not fully convincing yet. For this reason, we opted for a manual sentiment annotation process. We have selected 3500 reviews

[1] https://www.trustpilot.com/ The dataset is available from the authors by request,

randomly for the manual annotation and labeled each message according to the emotions found in the review. The data was annotated by two annotators, making use of three possible labels: positive, negative, and mixed. After the two annotators individually assigned sentiment values, every single disagreement was discussed until a consensus was reached. After resolving all the disagreements, we removed all the reviews of insufficient quality (e.g., too short, not comprehensible, not in English). The final dataset includes 3159 data points, consisting of 59% positive, 33% negative, and 8% mixed sentiment values. After the annotation, we performed text cleaning: transforming the text into lowercase, removing all the non-alpha characters, cleaning out the contractions, removing the HTML tags and URLs, and finally, lemmatization. After text processing, the total number of words is 108253 and the total number of unique words is 4766.

To perform sentiment classification on the reviews, the text of the reviews needs to be transformed into a set of features that is understandable for a classifier. The performance of the machine learning algorithms depends intensely on this feature extraction process, i.e. creating a feature vector representation (Zainuddin et al., 2014). In this article, we make use of two feature extraction methods: Bag of Words (BOW) and Term Frequency Inverse Document Frequency (TF-IDF). BOW is a feature extraction technique that takes text data as input and produces an unordered collection of the unique vocabulary of the documents to be used in further classification process (Barry, 2017). When using TF-IDF, 2 components are assigned to each word and combined to obtain a final representation (Dang et al., 2020): (i) term frequency outlines how often a specific word occurs within a document, while (ii) inverse document frequency estimates the informativeness of a word.

3.2 Machine learning models for sentiment classification

In order to build and compare different sentiment classification models for customer reviews, we have chosen the most frequently used models in sentiment analysis literature: Naïve Bayes, Support Vector Machines, and BERT. Additionally, we have selected RoBERTa, as one of the recently introduced methods, gaining interest and showing good performance in various applications.

The Naïve Bayes classification algorithm is based on Bayes' theorem, and uses the idea of identifying the most probable class using the conditional frequency of occurrences in terms of the feature vectors. Naïve Bayes' has been applied successfully in many domains, such as text classification, medical diagnosis, and systems performance management (Rish, I., 2001; Dey et al., 2016).

Support-vector Machines (SVM) were originally introduced by Vapnik et al., (1997). One of the advantages of SVM models, namely their ability to handle large numbers of features, makes SVMs a widely used choice in text classification problems (Zainuddin et al., 2014). SVMs have shown excellent performance in prior sentiment analysis studies (Mullen et al., 2004).

Additionally to the traditional machine learning techniques, we selected two recently introduced language transformer models: BERT and RoBERTa. RoBERTa (Liu et al., 2019) is a modified version of BERT; although transformers (Vaswani et al., 2017) are used in both models as the main architecture, RoBERTa is trained differently compared to BERT. The major modifications in training the RoBERTa model are: 1) the model is trained longer, with larger batches and data, 2) the next sentence prediction objective is removed, 3) using entire sentences as input, 4) text encoding, and 5) dynamic masking.

3.3 Model building

In order to identify the best-performing model, we tested different combinations of text feature extraction methods and machine learning algorithms. In the case of Naïve Bayes and SVM, we tested BOW and TF-IDF to transform the text to the numeric features, while for BERT and RoBERTa, we used a transformer tokenizer. Before model building, we divided the dataset into the train (80% of the data), validation (12%), and test (8%) sets. These sets were fixed for all the models, and we performed the analysis without any further resampling, such as cross-validation. As the dataset is imbalanced in terms of the number of labels, we used stratified random sampling. The validation set was used to identify the optimal cost parameters for the traditional machine learning models: (i) by changing the n-gram vectorizer parameters and regularization parameters for the linear SVM model, and (ii) n-gram vectorizer parameters and the α value for Multinomial Naïve Bayes. The same steps were performed for SVM and Naïve Bayes with BOW and TF-IDF features to

compare the performance, and the best performing model in each case is selected as the one minimizing the number of misclassifications.

For text transformation in transformer-based models, we utilized tokenizers (AutoTokenizer for BERT, and RobertaTokenizer for RoBERTa). For BERT, we used the main model as the baseline, and added a dropout layer to control overfitting, and a dense layer for the classification task. When training RoBERTa, in addition to a dropout of 0.3 and a Linear layer, our network model includes the main model with 12 layers and 768 hidden dimensions. For both BERT and RoBERTa, the optimizer, loss function, and performance metric were specified as Adam, categorical cross-entropy, and accuracy, respectively.

To evaluate the performance of the models, we made use of some traditionally employed measures, namely accuracy and F1. Various measures of classification performance with binary outcome (positive and negative classes) can be defined using the confusion matrix. It has four components: (i) true positives (TP, positive cases correctly classified as positive), (ii) true negatives (TN, negative cases correctly classified as negative), (iii) false positives (FP, negative cases incorrectly classified as positive), and (iv) false negatives (FN, positive cases incorrectly classified as negative). Using these notions, accuracy can simply be defined as the percentage of correctly classified cases, i.e., (TP+TN)/(TP+TN+FP+FN). This is the most widel used measure, although it has several issues, in particular in problems with imbalanced cases. One alternative measure is F1, which is defined as TP/(TP + 0.5(FP + FN)).

4 Results

In this section, we will present the results of the experiments and show the performance of the various machine learning models in sentiment classification, and compare our results to previous academic research. Furthermore, we discuss some observations highly relevant in managing expectations regarding this performance and provide illustrations using the constructed models.

4.1 Sentiment classification performance

Altogether, six different models were constructed as discussed in the previous section; the results (the best performance for all models after extensive parameter selection) are presented in Table 1. In the table, we present the accuracy and F1 value for the test set (and as a comparison to the validation set), the number of misclassifications in the test set, and the execution time of building the models.

Method	**Validation set accuracy**	F1 on validation set	**Test set accuracy**	**F1 on test set**	**Number of misclassification (test set)**	**Execution time(in seconds)**
Naive Bayes (TFIDF)	0.868	0.889	0.901	0.889	25	0.720
Naive Bayes (BOW)	0.889	0.883	0.916	0.906	21	5.493
SVM (BOW)	0.862	0.854	0.873	0.866	32	10.581
SVM (TFIDF)	0.907	0.895	0.905	0.889	24	1.192
BERT	0.902	0.889	0.921	0.899	20	1132.78
RoBERTa	**0.976**	**0.984**	**0.988**	**0.992**	**3**	378

Table 1: Sentiment classification performance

The results reveal some interesting insights. First of all, it is clear from the performance evaluation that language transformer-based models are superior to traditional machine learning models. Furthermore, RoBERTa outperforms even BERT significantly, with accuracy on the test set above 98%. Second, considering only the traditional ML models, the best accuracy can be achieved by Naive Bayes in combination with Bag of Words. Interestingly, SVMs perform better when used with features extracted with TF-IDF. Finally, regarding execution time, as it can be expected, transformer-based models take more time to train, which is the cost for the improved performance.

Regarding the specific misclassifications generated by the RoBERTa model, the mistakes are coming from identifying the Mixed polarity. It is not unexpected, as the number of reviews with Mixed polarity is fewer than the other 2 polarities. As an example misclassification, the following review was misclassified as Positive instead of Mixed:

I previously wrote a very angry review, as I paid for faster shipping and it hasn't been delivered any faster. This being said, SheInside saw my review and offered to compensate for the extra shipping costs. It was more the principle than anything—I hate feeling scammed. SheInside fixed those feelings and contacted me to solve my issue. Thank you!

4.2 Discussion

In the following, we will discuss the performance presented above from both a technical perspective and also the relevance for companies. First, regarding our main results, we have identified contributions from the literature that presented sentiment classification on user reviews (Fang et al., 2015; Nanda et al., 2018; Dey et al., 2016; Colón-Ruiz et al., 2020; Basani et al., 2019; Munna et al., 2020; Pipalia et al., 2020). SVM (e.g. Colón-Ruiz et al., 2020), Naive Bayes (e.g. Basani et al., 2019), and Neural Network models (Munna et al., 2020) are some of the most widely used methods in the sentiment classification task, i.e. the same models we have tested in this article. Although performance results are not directly comparable to previous research as we focused on a new dataset, our results with regards to traditional models align with previous findings: accuracy in the range of 85-95% is achievable, depending on the domain and also the language of the reviews. This can also be seen as a promising performance considering the execution time and simplicity of building such models for business applications. In our experiments, the neural network-based transformer models seem to offer the best performance, which is in line with the very limited amount of research available.

Providing the input for classification models, data annotation, i.e., assigning sentiment polarity to the reviews, plays a crucial role. In the literature, machine labeling (e.g. Fang et al., 2015) and manual annotation (e.g. Munna et al, 2020) are the most used annotation methods. Automated annotations are less expensive in terms of time and cost in comparison to manual annotation, however in general they are less accurate. In this research, we chose manual annotation to acquire an

understanding of the content of the reviews as related to the target companies. A third alternative approach to assign a sentiment to reviews would be to use the rating provided by the users, as it is done for example by Pipalia et al. (2020). Our manual inspection during the annotation process has shown that this approach could be problematic, as there are a large number of reviews when there is a disagreement between the rating and the sentiment of the review. For example, the following review was accompanied with the rating of 5 (on a 1-5 scale, with 5 being the highest value), although it is clear that the associated sentiment should be Negative:

"Some items are too expensive on the shipment and is too long for the wait"

The following is a similar example with the rating of 5 but clearly not a Positive sentiment:

I ordered a big clock for my wall it came in so very small I want the big one please

As these and numerous similar examples show, using the rating can be deteriorating for the performance of sentiment classification. Companies should be careful when assessing their popularity and the sentiment level of customers based on ratings. As our results show, manually annotating a subset of reviews can result in models that can offer close to perfect sentiment polarity classification. In fact, the following example from our test set was correctly classified as Negative, while the original user rating was 4:

Deliveries take too long. Postage added is a turn off

The following example review was also classified as Negative, although the user rating was 4:

My order says shipped but has no information on its whereabouts. It only said "processing" for about a day before it said my order was shipped. I'm confused

As a final point relevant to businesses, we can note that the best sentiment classification model, RoBERTa, has performed equally well across the different shops present in the data. The accuracy was observed as follows: 97% for Boozt, 98% for Nelly, 100% for Sheinside, 100% for Wish, and 98% for Zalando. These results illustrate the great potential of transformer-based models in sentiment classification.

5 Conclusions

With the wide availability of unstructured big data, in particular textual information in the form of customer reviews, we observed a rapid development in data processing and analysis techniques to make sense of all this information. Sentiment analysis has been discussed and evaluated numerous times in the literature, however, since there is a plethora of new models appearing, it is always an important task to critically assess and compare new and established models. In particular for e-commerce platforms, sentiment analysis of online reviews can be the main source of information to understand the opinions of customers. In this article, we have compared the performance of traditional machine learning models with language transformer models, and found that the neural network-based models offer much higher accuracy in sentiment classification tasks. We illustrated the value of manual annotation through several examples of problems with user ratings that can be avoided by the sentiment classification models built using manually assigned sentiment values.

Regarding future research, the most important continuation of the work will focus on performing aspect-based sentiment classification. While we have shown that very high performance can be achieved using transformer-based models, this is sufficient to understand the reasons for the polarity of sentiments. In the case of the analyzed reviews of e-commerce stores, instead of assigning a general sentiment, one could assess the sentiment polarity with respect to, e.g., shipping, received item quality, payment process. By constructing models that can identify the core aspects in the reviews and the associated sentiment, companies will know where to focus their efforts to improve customer satisfaction. Additionally, some limitations of the study have to be acknowledged. First, we cannot say that the sample of reviews is representative in any way, so models need to be tested on larger datasets and different e-commerce stores. Second, while the annotation was performed and then cross-checked by two researchers, there is still a possibility of incorrect sentiment assignments, which in turn may impact the constructed models and performance. Third, while we used the models most frequently utilized in the sentiment classification literature, there are numerous machine learning models available that could be tested for performance.

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BARRIERS FOR SMES IN ADOPTING CROWDSOURCING

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Abstract Despite its undisputable benefits for firms, crowdsourcing is rarely applied in small and medium sized enterprises (SME), yet. Until today extant literature provides only an uncomplete picture of the barriers that hinder SMEs from adopting crowdsourcing. Because of these incomplete insights on this phenomenon there is a great deal of uncertainty on how to overcome these barriers all the more. In the scope of an interview series with 15 SMEs we explore a range of different barriers. The findings from our study do not only expand the so far incomplete body of knowledge but also provide practical references for SMEs to be aware of the barriers. This simplifies avoiding them and successfully adopting crowdsourcing.

Keywords:
SME, crowdsourcing, crowdworking, barriers, challenges.

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1 Introduction

Crowdsourcing is flourishing. As of today, especially large companies benefit from crowdsourcing. Crowdsourcing is the process of outsourcing tasks to an unknown mass of people via the internet (Howe, 2006; Majchrzak, 2020). It enables organizations to get external support for different value creating activities. For example, Starbucks applied crowdsourcing for their new product development (NPD) (Hsiang & Rayz, 2020). They were asking the crowd for ideas to improve the experience at the coffee place. For more than 10 years Starbucks customers (representing the crowd) were called to upload their improvement suggestions to a platform called "*MyStarbucksIdea.com*" (Hsiang & Rayz, 2020; Bretschneider, Leimeister, & Mathiassen, 2015). This way, splash sticks (which keep to-go drinks in the cup), new coffee creations and free store Wi-Fi were introduced (Hsiang & Rayz, 2020). Another example involves PepsiCo, who applied a crowdsourcing strategy for their marketing activities. PepsiCo was running several crowdsourcing campaigns, called "*Do Us a Flavor*", for its potato chips brand "*Lay*" (Sanz-Blas, Tena-Monferrer, & Sánchez-García, 2015). Different new potato chip flavors were handed in by individuals. To identify the most popular ones, the crowd could vote on their preferred suggestion(s). After the campaign was completed, PepsiCo brought the three most popular flavors to the market (Sanz-Blas et al., 2015).

Despite its increasing recognition, dissemination, and success in larger organizations, crowdsourcing is rarely applied in small and medium sized enterprises (SMEs) (Mrass and Peters 2017; Qin, van der Velde, Chatzakis, McStea, & Smith, 2016). This observation is surprising since adopting crowdsourcing seems to be particularly worthwhile for SMEs. In general, SMEs are known for having limited manpower for completing tasks that are outside their core competences (Erickson, 2012; Nakanishi & Syozugawa, 2021). Thus, crowdsourcing provides great potential to reduce employee's workload. Further, SMEs are discussed to have less bureaucracy and shorter decision-making processes (Brien & Hamburg, 2014, 62), which per se is attractive for applying crowdsourcing.

Until today, crowdsourcing scholars have only insufficiently researched the reasons why SMEs are shy of applying it. Existing literature provides an uncomplete picture of the barriers that hinder SMEs from adopting crowdsourcing (Qin et al., 2016).

Because of incomplete insights on barriers, there is also great uncertainty on how to overcome them (Qin et al., 2016).

Against this background, the aim of this paper is to identify and describe barriers that SMEs face when applying crowdsourcing. The underlying research question is as follows: *RQ: "Which barriers hinder SMEs in adopting crowdsourcing in their value creation?"*

For exploring the barriers, we applied a qualitative research approach. We interviewed 18 representatives from 15 SMEs. The findings from our study do not only expand the so far incomplete body of knowledge, but also provide practical references for SMEs to overcome the barriers and to adopt crowdsourcing for their value-creating activities.

2 Theoretical Background

2.1 Crowdsourcing and Crowdworking

In this paper we define *crowdsourcing* as the execution of contracting out a task to an anonymous group of people via the internet. This definition is inter alia in accordance with Nakanishi and Syozugawa (2021), Blohm et al. (2013), Estellés-Arolas and González-Ladrón-de-Guevara (2012) and Afuah and Tucci (2012).

The task given to the crowd can be remunerated or non-remunerated (Blohm et al., 2013; Kittur et al., 2013). Crowdsourcing is characterized by no monetary remuneration. In some cases, the crowd receives freebies when they are solving a task. In most instances the crowd is not compensated as they are intrinsically motivated and enjoy contributing to an organization's value creation (Estellés-Arolas and González-Ladrón-de-Guevara, 2012). Whenever a task is remunerated, one is talking about *crowdworking*. Crowdworking is a subcategory of crowdsourcing (Durward, Blohm, & Leimeister, 2016). The crowdworking concept differs from crowdsourcing in that a task is outsourced to an individual and not to several people. A precise task description is uploaded to a fitting platform and crowdworkers willing to conduct the job need to apply for it. Thereafter, the organization is screening potential contractors and selects an individual. After the selected crowdworker has completed the task and the contracting organization is satisfied with the task handed in, the crowdworker receives the in advance defined remuneration. Thus, in the

context of crowdworking, individuals are extrinsically motivated and have the goal of creating income via online labor platforms (Durward et al., 2016). Durward et al. describe crowdworking as "*digital gainful employment based on crowdsourcing*" (2016, 283).

In the context of crowdsourcing and crowdworking, one differentiates between micro and macrotasks. Micro tasks cover parts that are repetitive and can be done without a certain set of skills (Gol, Stein, & Avital, 2019; Stefano, 2015). Completing surveys, tagging images, testing webpages, or training an artificial intelligence are common microtasks. These assignments are easy and clear to describe, they can be completed within a short period of time and do not require certain qualification. Due to higher complexity, macrotasks often require skilled workers. When conducting macrotasks, the crowd gets greater insights into the entire project. This is necessary to conclude the job. These macrotask campaigns are often announced for new product development projects, for designing logos and advancing new product development (Majchrzak & Malhotra, 2013; Boons & Stam, 2019). Organizations can benefit from handing out macrotasks to a crowd as this process supports generating external knowledge and promotes idea and innovation creation (Ricardo Buettner, 2015; Gol et al., 2019; Margaryan, 2016).

For bringing the crowd and the organization together, platforms with different focusses act as an intermediary. Some platforms specialize on crowdworking, others focus on crowdsourcing. Also, platforms differ contextually. While some focus on clicktasks, others aim attention at design tasks and small development tasks. Well known platforms for clicktasks, are clickworker and Amazon Mechanical Turk. A popular platform for macrotasks is Upwork. Any communication between the organization and the individual/crowd occurs via the platform through which all work processes and activities are managed (Kittur et al., 2013).

Recently crowdsourcing has often been referred to as on-demand workforce or as a form of online labor (Taylor & Joshi, 2018) with high economic potential (Fuller, Raman, Bailey, & Vaduganathan, 2020). According to Fuller et al., "*almost 90% of business leaders reported talent platforms would be somewhat or very important to their organization's future competitive advantage*" (November 2020, 2).

2.2 SMEs in Germany

With over 95% of all companies in Europe and over 99% of all companies in Germany (European Commission, 2015), SMEs present an important building block for the European economy.

According to the European Commission, SMEs are organizations that "*employ fewer than 250 employees and have either an annual turnover not exceeding 50 million Euro or an annual balance sheet total not exceeding than 43 million Euro*" (European Commission, 2015). If these values are exceeded, the organization is defined as a large organization. According to Becker and Ulrich (2009) those quantitative categories only present approximate values to identify SMEs. Common qualitative categories to classify organizations into SMEs include *"(1) the company's economic and legal independence, (2) the unity of ownership, control, and management as well as (3) a close link between the company and its owners*" (Hausch, 2004, 15).

According to Berrone et al. (2012), the SMEs employees' personal commitment, their company loyalty (Miller & Le Breton-Miller, 2006) and the firm's high innovation potential make themselves to candidates for successfully introducing digital transformation and new ways of working such as crowdsourcing and crowdworking. Low hierarchy levels, short decision making paths and flexibility are further characteristics that distinguish SMEs from larger organizations. Due to less employees the organization chart within SMEs is less complex and there are fewer hierarchical levels than there are in large organizations. All these conditions theoretically simplify adopting crowdsourcing in organizations. However, introducing changes and new ways of working in SMEs can be challenging. Developing and building up capabilities for those changes presents additional effort for traditionally oriented organizations (Soluk & Kammerlander, 2021; Nambisan, Lyytinen, Majchrzak, & Song, 2017; Sambamurthy, Bharadwaj, & Grover, 2003; Yoo, 2013). SMEs often associate such alterations with additional costs and effort. Thus, they do not perceive crowdsourcing as suitable for everyday use (Gómez-Mejía, Haynes, Núñez-Nickel, Jacobson, & Moyano-Fuentes, 2007). Furthermore, SMEs do not associate long-term benefits such as sustainable competitiveness by exploring new horizons in the digital environment (Soluk, Miroshnychenko, Kammerlander, & Massis, 2021).

3 Methodology

To identify barriers that SMEs face when introducing crowdsourcing, we conducted 15 open interviews with 18 site managers, managing directors and CEOs from different industries. With this data collection approach and according to recent research, we reached meaning saturation (Hennink, Kaiser, & Marconi, 2017). Most of the interviewed experts come from the production industry, the mobility industry, and the metalworking industry. To identify our interview partners, we sent out a survey to 30 SMEs from various industries. For the dialogues, we approached those firms that indicated being interested in introducing crowdsourcing in the survey. During the interviews we asked them to freely explain their personal attitudes, values, beliefs, and views on crowdsourcing. To allow an extensive interaction with the interviewees and to uncover unexpected or unanticipated information, we carried out the interviews as unstructured as possible (Schultze & Avital, 2011). Because of the uncertain pandemic situation during the data collection period, nine of the interviews were conducted via video or telephone conference. The remaining six were carried out on site of the relative organization. The discussions lasted between 60 and 100 minutes; we recorded them with prior consent.

In line with Strauss and Corbin's grounded theory approach, we involved new insights and discussion questions that developed throughout previous interviews (Charmaz, 2014). During the conversations, we started with general questions about the company, the interview partner, and their experience with crowdsourcing and crowdworking. In the main part of the interview, we investigated current barriers that SMEs face when applying crowdsourcing. We asked the interlocutors about reasons for their reluctance and challenges for not implementing this new way of working. In the final part of the interview, we gave them the opportunity to share anything with us that was not mentioned yet.

After conducting and transcribing the interviews, we started rereading all statements. This allowed us to cluster the different phenomena that we identified based on the open coding procedure. After clustering, labelling, and conceptualizing the different phenomena, we added a label to each of the clusters (Strauss, 1997). The resulting codes presented the basis for the axial coding process, in which we grouped similar codes. For each of the codes we identified a category (= heading). Interlinking those

categories allowed us to phrase theory building blocks for the analyzed research question (Strauss, 1997).

4 Findings

The **first barrier** that SMEs are confronted with when applying crowdsourcing is the risk of quality issues induced by the crowd. While SMEs want the crowdsourcees/crowdworkers to provide high-quality solutions at low prices, the crowdsourcees/crowdworkers want to complete the job as fast as possible and with at least effort as possible ("*With the salaries paid to the crowdworkers, it is not surprising that they want to complete them as fast as possible.*", interviewee 6). Besides, the interviews show that the credibility of documents uploaded to the platform is lower than a certified copy attached to a conventional application ("*Having a job reference on paper is different from mentioning it online that you worked for Volkswagen, Mercedes or whomever.*", interviewee 2, "*I needed to check the qualifications of the people that work for me.*", interviewee 4).

Two interviewees stated that in case of poor-quality products or services SMEs might face image losses, lawsuits, and complaints. Depending on the extent, poor delivered quality products or services can drive SMEs into insolvency. As the contracting authority enters an agreement with the online labor platform and the online labor platform enters an agreement with the crowdworker(s), SMEs have limited legal claims against them (Gimpel et al., 2020; interviewee 4).

Since the crowd (including crowdworkers) do not enter a contract with SMEs, they have limited claims against them. This entails that SMEs are liable for poor quality products or services that are delivered to the customers („*The lack of responsibility on the client's side is often criticized, but when advocating minimum wages for crowdworkers, one has to take into consideration that both sides have very few obligations.*" (Schmidt, 2017b, 16)).

The **second barrier** that we identified is the management's reluctance towards crowdsourcing, including crowdworking. Managing directors of SMEs are often experienced executives. Because of their traditional ways of doing business, they prefer to hire permanent employees over crowdworkers ("*Of course, in a traditional company, for instance a 150-year-old company, a CEO won't be in a situation of cost pressure. Therefore, he would rather hire someone fulltime instead of dealing with [a platform provider such as] Textbroker.*", interviewee 9). In the context of implementing new forms of labor,

interviewees see a time-consuming effort of coordinating crowdworkers. The interviewees fear that the coordination effort is more time intensive than doing the job themselves ("*then I need to do the work twice. As soon as I signed [the transmittals] I am the one that needs to make sure that the transmission is safe. If it's not safe, then I need to recalculate it. That means that I don't economize anything.*", interviewee 8). Delivered solutions by crowdworkers with uncertain skills and qualifications require intensive quality evaluation by internal employees (interviewee 6). Having heard about negative incidents such as underestimating the required coordination effort and "*facing something new*" hinders managers of SMEs from introducing crowdworking (interviewee 10).

As many SMEs are offering specialized goods and services, the interlocutors perceive it as difficult and "*in some cases [as] impossible*" to find an appropriate crowdworker (interviewee 5). Projects and tasks that require specific knowledge are not suited for being handed over to a crowdworker (interviewee 4). Losing the identity of a SME by introducing crowdsourcing and crowdworking is a further concern that managers have. This phenomenon is known as the "*not invented here syndrome*" (interviewee 14, 15). The "*not invented here*" and "*not sold here*" syndromes describe the aversion against ideas that were developed externally (Dubouloz, Bocquet, Equey Balzli, Gardet, & Gandia, 2021, 116).

The **third barrier** that SMEs face when establishing crowdsourcing and crowdworking is the employees' reluctance. New ways of on-demand work force models contradict the close personal relationships that colleagues in SMEs have ("*Our staff is more than just employees. They are part of a family like network*", interviewee 11). Having external workers taking part in everyday business increases the pressure and competition between permanent employees and crowdworkers ("*That means you become an internal freelancer, so to speak, and that's sometimes not nice when working, because you are seen differently. You are no longer perceived as an essential component in terms of appreciation.*", interviewee 8).

The **fourth identified barrier** is the increased risk of losing sensitive information when applying crowdsourcing and crowdworking. SMEs' secrets and their sensitive information are often protected with patents, trade secrets or copyrights. These copyrights on an invention are extremely relevant for the SMEs' value creation; many of these firms have been successful with the same or a further developed

business model since their founding ("*We cannot hand over tasks that require certain knowldge of our internal affairs.*").

The **fifth barrier** that we identified is the coordination effort that comes along with crowdsourcing. Before the crowd overtakes a task, an appropriate group and a suitable platform needs to be identified. After having determined both, a precise task description is written ("*You need to know how to ask questions correctly and understand them accordingly. It's always a question of what you write and how others understand it.*", interviewee 12; "*Yes, complex tasks need to be described more detailed than simple tasks* ", interviewee 1).

As soon as the crowd has completed the task, submitted solutions need to be screened. Gathering and evaluating these answers is time-consuming and presents additional effort for SMEs ("*As an SME, we are busy with our tasks. I need the crowd to do the work for me and I don't have the capacity to control and coordinate them permanently.*", interviewee 1). Whenever crowdsourcing is practiced, it is important to "*ensure that the quality management system established in the company is also applied […] by the crowd*" (interviewee 15). Getting hired for different projects and by different organizations makes it impossible for the crowd to familiarize themselves with the internal processes and quality expectations of different firms (interviewee 2, 13, 14, 15). Kickoff meetings which are identified as substantial in project management cannot be implemented if the crowd is overtaking certain tasks ("*In practice, I ideally have a kick-off in which all participants or project/planners, programmers are meeting. That facilitates being on the same boat from the beginning of the project on*", interviewee 1).

The **sixth barrier** that SMEs face when introducing crowdsourcing is their specific requirements. These requirements include quality and legal standards which are extremely relevant for SMEs following a niche or a one product strategy. Companies that generate their sales with one or a few products are under greater pressure to deliver highest quality standards. It is necessary for meeting the few customers' specific expectations. Poor delivered quality can lead to losing the few customers and, in the worst case, it pushes SMEs into an existential threat. As large companies are more diversified in terms of products and have more clients, they have a higher chance to continue their business in case they lost one or more clients due to quality flaws.

Next to the higher risk that SMEs have when delivering insufficient quality, legal guidelines are highly complex in the SMEs' environment. Getting familiar with those specifications takes time. Therefore, it is clear for interviewees that certain tasks cannot be outsourced to the crowd („*I can't just handout certain tasks to someone who has a good idea, but they also have to know and understand the industry specific rules and quality requirements*.", interviewee 5, 11, 13).

5 Analysis and Discussion

After having presented the barriers that SMEs face when introducing crowdsourcing, we will now explain the barrier categories through specific characteristics of SMEs. Thereby we follow a clearly structured theoretical logic as well as point out the barrier categories through generic management theories.

The **first barrier**, the risk of quality issues induced by the crowd, can be explained by the principal agent theory and the associated information asymmetries. The principal (in our case the crowdsourcer = SME) and the agent (in our case the crowdsourcee/crowdworker) have conflicting interests as both are acting according to their own best benefit (Sappington, 1991). It brings the crowdsourcers (= principal = SME) in an underprivileged situation as crowdsourcee/crowdworker (= agent/s) do focus on completing the task as fast as possible.

As SMEs generally follow a niche or a one product strategy, their business depends on few customers (Santoro, Ferraris, Giacosa, & Giovando, 2018). A faulty and substandard performance of tasks that lead to quality issues can contribute to existential threats for SMEs (Raymond & St-Pierre, 2004). Potential risk failures have greater existential consequences for the analyzed organizations than similar defects can have for large companies (Qin et al., 2016). This is why interviewees fear redoing tasks executed by the crowd due to lack of quality (Qin et al., 2016; interviewee 3, 4, 7). Such a scenario presented double the workload and thus crowdsourcing loses its attractiveness (Qin et al., 2016; interviewee 4).

The **second barrier** coves transaction costs and the management's reluctance towards crowdsourcing. Because of their traditional and conservative mindset, many SMEs have little interest in innovation, new organizational forms, or novel work approaches (Morck & Yeung, 2003; Gómez-Mejía et al., 2007, 134). Their

mistrustful perspective on digital technologies intensifies the unwillingness to engage with digital initiatives (Soluk & Kammerlander, 2021). This hesitation impedes crowdsourcing and crowdworking in SMEs (interviewee 15). Besides, managers fear that crowdworking does not fit into the organizational structure (Berrone et al., 2012, 269). According to Qin et al. (2016), managers "*[have a] (1) lack of awareness of crowdsourcing systems and applications, (2) fear changing established business models, (3) [have] trust and confidentiality issues in the open and digital environment, and (4) [they] lack appropriate and flexible platforms that meet the contextual, relational and situational needs of SMEs.*" (1062). Unawareness and low likelihood of diversifying technologically (Berrone et al., 2012, 260) are further reasons for managers' reluctance towards crowdsourcing in SMEs. Strategies and approaches need to be identified to make on-demand work force more attractive.

The **third barrier** (the employee's reluctance) is characterized by intra-organizational relationships among employees. These relationships are more important than in larger companies as the family-like connections are essential for a company culture of SMEs (Kmecova & Tlusty, 2021). When new ways of flexible working are implemented, permanent staff fear losing their job and the positive working atmosphere ("*In general, it can be said that the extreme competition between the individuals in the creative crowd can cause a toxic work climate.*" (Schmidt, 2017b, 18)). As Berrone et al. identified in 2012, social emotional wealth (SEW) plays an important role in family possessed firms („*it [the SEW] accounts for nonfinancial aspects, and it contemplates both positive and negative consequences of these noneconomic aspects.*" (Berrone et al., 2012, 274)). A SEW describes the firm's values and goals which they have apart from maximizing value creation. Examples for those values are "*family control and influence, identification of family members with the firm, binding social ties, emotional attachment of family members, and a renewal of family bonds to the firm through dynastic succession.*" (Berrone et al., 2012, 259). Those dimensions are in the core of a family's business model and their decisions („*family firms' sense of belonging, self, and identity are often shared by nonfamily employees, promoting a sense of stability and commitment to the firm*" (Miller & Le Breton-Miller, 2006; Berrone et al., 2012, 263)).

Employees anticipate that family firm's core values get lost as soon as the crowd overtakes tasks. Stringent control of the crowdsourcee's and the crowdworker's performance contradicts the SEW and the low hierarchy within SMEs ("*Performance is directly and closely controlled through a so-called work diary: a software tool periodically takes*

snapshots of the [crowd]workers' computer screens or counts the keystrokes" Kittur et al., 2013). The ability of taking advantage of absorptive capacity puts organizations in a situation in which they are flooded with solutions and ideas (Cohen & Levinthal, 2008). It necessitates to screen all the ideas to evaluate their value for the organization. Not being able to filter the best ideas hinders SMEs to benefit from the absorptive capacity. Absorptive capacity is *"[the] ability to recognize the value of new information, assimilate it, and apply it to commercial ends*" (Cohen & Levinthal, 2008, 128). According to Raymond and St-Pierre not including novel concepts submitted in by the crowd can lead to "*over-specializing their [the SME's] firm and neglecting its development and adaption required to survive and prosper in the longer term within an ever-changing business environment*", (Raymond & St-Pierre, 2004, 25).

The increased risk of losing sensitive information (**fourth barrier**) is especially threatening for SMEs as patents are extremely relevant for the SMEs' value creation; many of these firms have been successful with the same or a further developed business model since their founding. Other than bigger organizations, SMEs often follow a niche strategy and thus their existance depends on one or a few products (Maleewat & Banjongprasert, 2022).

The **fifth barrier** that we identified is the coordination effort that comes along with crowdsourcing. As especially SMEs have skills shortage, they cannot make use of absorptive capacity since they do not have the resources for sighting and evaluating all solutions handed in by the crowd. Absorptive capacity refers to the ability of a recipient to assimilate value and use the knowledge transferred (Cohen & Levinthal, 2008). Even though crowdsourcing has great potential for SMEs to get external knowledge and a great variety of ideas, the interviewees and literature agree that „*not every job can be outsourced to the crowd*" (Schmidt, 2017a, 23; interviewee 2, 4, 14).

The **last barrier** identified is the firm's specific quality and legal requirements. This finding gets supported by Greineder and Blohm who emphasize that crowdsourcing "*is not only about evaluating the output but also about carrying out secondary tasks such as finding errors, identifying duplicates and providing targeted feedback.*" (2020, 12).

6 Conclusion

6.1 Contribution to Theory and Managerial Implications

This research offers both academic and practical value. As it concerns the academic value, our research contributes to the body of knowledge on crowdsourcing and crowdworking. Although scholars are looking at this phenomenon for many years now, research on barriers of SMEs adopting crowdsourcing is still in its infancy. Qin et al. (2016) are one of the rare scholars who researched this phenomenon. For example, Quin et al. (2016) identified „*unawareness of tools/models*" as well as „*no appropriate platforms*" as barriers that hinder SMEs from adopting crowdsourcing. However, these insights solely cover the technical view on the phenomenon. At large, extant literature so-far only provides an uncomplete picture of the phenomenon of interest. Against this background, our findings cover the managerial and organizational perspective of crowdsourcing and therefore expand the body of knowledge by presenting additional perspectives. This study also provides validation of two specific barriers that already have been partially identified by Quin et al. (2016). In their work Quin et al. (2016) propose "*internal culture*" as well as „*trust/confidentiality issues*", which correspond with our „*Employee's Reluctance*" (third barrier) respectively "*Risk of Quality Issues*" (first barrier) barriers. Beside the mentioned validation our findings even constitute a refinement of the first work by Quin et al. (2016).

6.2 Limitations and Further Research

Our study provides a broad insight in barriers that German SMEs currently face when introducing crowdsourcing. Besides, we empirically developed barriers that SMEs hinder from implementing crowdsourcing. The basis for our results is 15 conducted interviews with 18 representatives from different industries. One limitation of our study is that we only interviewed managers and department heads but did not talk to the workers who play an important role in implementing crowdsourcing. In a second step, their perception could be compared to our findings and discrepancies could be developed. The interviews that we conducted with managers allowed us to get an overarching overview of company related, employee related and management related barriers for introducing crowdsourcing in SMEs. A

longitudinal study with employees might reveal other or additional valuable insights with respect to the identified barriers.

A second limitation is that we focused on SMEs in one country. Only focusing on SMEs in one country ensures a high comparability of the findings. This is because structures and challenges in SMEs within one country are alike. Taking our study and results as a basis and conducting the same investigation in other countries increases the results' generalizability. Country specific barriers can be identified.

A third limitation is that we interviewed representatives from different industries. This gave us the opportunity to get a brought inside into current challenges and barriers that SMEs in different industries face. At the same time, it would be interesting to identify which industry specific hurdles exist. Our study does not have a focus on industry specific barriers and thus our results are more brought. In future research these industry specific difficulties can be detained, and specificities be compared.

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Digitization and New Work: A Qualitative Guide for Small and Medium-Sized Enterprises to Take Action

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Abstract The Western world is currently facing a persistent shortage of skilled workers. Well-trained employees are difficult to find and even more challenging to retain. Employees, therefore, expect the best working conditions. Companies initiate New Work approaches in response to dynamic changes. This study examines the requirements for New Work design from the perspective of commercial employees to offer small and medium-sized enterprises (SMEs) guidance to find the optimal workplace development for their employees. A qualitative research method in the form of guided interviews was used to explore the needs of employees. The results suggest that employees desire an adapted work structure and change in the sense of New Work. Based on the study results, seven design areas were derived and recommendations for action were developed for the respective areas. Requirements and patterns are identified across several principles and design areas. Based on the results, strategies for implementation were developed.

Keywords: new work, employees, qualitative research.

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1 Introduction

The world of work is undergoing continuous change.[1] Digitization, in particular, is a current driver of change.[2] The digital world of work is becoming increasingly scattered. However, at the same time, individuals have emancipated[3] themselves with steadily growing demands to organize and adjust work and life, while work becomes more critical.[4] These developments may impact the way individuals work in the future.[5]

Nevertheless, companies often consider rigid work models.[6] Equating work with fixed working hours, a stagnant job in the company under corporate supervision, strict hierarchies, and long-term employment does not reflect current opportunities presented by digitalization.[7] Companies need to understand that they cannot introduce new approaches while holding on to old concepts.[8] New technologies, digital exhaustion, constant accessibility, work intensification, and increased mobility are just phenomena leading to increasingly demanding and complex working conditions. The desire for working conditions that are stimulating and facilitating is growing, resulting in new requirements for work design as well as individual demands.[9]

In response to dynamic changes in the world of work and the demands of employees, organizations are initiating New Work approaches that focus on people and attempt to formulate recommendations for action by organizations.[10] New Work may affect everyone, such that most companies recognize the need to affect change. The question arises to which strategies they should pursue. New Work is not yet tangible for managers and human resource (HR) staff, and there is blurriness

[1] Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2016, p. 4.
[2] Cf. Fichtner-Rosada, S.; Hermeier, B. ; Heupel, T., Arbeitswelten, 2019, p. 291; Cf. Nagel, L., Covid-19 digital transformation of work, 2020, p. 862.
[3] Cf. Eifert, T., New Work Health Style, 2014, p. 34 and Cf. Fichtner-Rosada, S.; Hermeier, B.; Heupel, T., Arbeitswelten, 2019), p. 164.
[4] Cf. Fortmann, H.R.; Kolocek, B. , Arbeitswelt der Zukunft, 2018, p. 5.
[5] Cf. Cloots, A.; Wörwag, S., Zukunft Arbeit, 2018, p. V.
[6] Cf. Fortmann, H.R.; Kolocek, B., Arbeitswelt der Zukunft, 2018, p. 302.
[7] Cf. Aroles, J.; Mitev, N.; Vaujany, F., new work, 2019, p. 290.
[8] Cf. Fortmann, H.R.; Kolocek, B., Arbeitswelt der Zukunft, 2018, p. 11.
[9] Cf. Fortmann, H.R.; Kolocek, B., Arbeitswelt der Zukunft, 2018, p. 131 and Cf. Becker, J. K., von der Oelsnitz, D., Sinnerfülltes Arbeiten, 2017, p. 4.
[10] Cf. Koch, J.; Schermuly, C. C., Digitalisierung, 2019, p. 128 and Cf. Fortmann, H.R.; Kolocek, B., Arbeitswelt der Zukunft, 2018, p. 84.

to find a state-of-the-art procedure to implement it.[11] Similarly, research has not advanced significantly.[12] There is no universally valid concept for New Work design that can be introduced as a standard.[13]

Against this background, the question arises: What are the requirements for SMEs to design New Work from employees' perspectives against the backdrop of digitalization?

This study examines the requirements for designing New Work from the perspective of commercial SME employees. The aim is to understand which structures employees need or desire regarding New Work. Within the study framework, potential concepts are identified. Finally, recommendations for action and assistance by companies are developed.

2 State of research

"New Work" was defined by Frithjof Bergmann, the Austrian-US philosopher, anthropologist, and founder of the New Work movement.[14] As early as the 1970s[15], Frithjof Bergmann was concerned with the relationship between people and work.[16] He developed an alternative model to wage labor and the capitalist maxim of constant growth *á la citius, altius, fortius* (faster, higher, stronger/further) under the term "New Work."[17] "The goal of New Work is not to free people from work, but to transform work so that it produces free, self-determined, human beings. It is not us who should serve work, but work that should serve us." [18]

Since then, Frithjof Bergmann has been regarded as the founder of the New Work movement[19] and a pioneer of modern work culture.

[11] Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. VI and Cf. Fortmann, H.R.; Kolocek, B. , Arbeitswelt der Zukunft, 2018, p. 1.
[12] Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. 1.
[13] Cf. Fortmann, H.R.; Kolocek, B. , Arbeitswelt der Zukunft, 2018, p. 1 and Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. 108.
[14] Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. 3.
[15] Cf. Käufer, T., Neue Arbeitswelt, 2019, p. 13.
[16] Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. 3.
[17] Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. 3.
[18] Bergmann, F.; Friedland, S. New Work, 2020, pp. 25-26.
[19] Cf. Fortmann, H.R.; Kolocek, B. , Arbeitswelt der Zukunft, 2018, p. 268.

Today, New Work represents a change of vision concerning entrepreneurially performed work.[20] It aims for a more humane future for the working world[21] with meaningful and fulfilling activities in more accessible and flexible work structures.[22] New Work is intended to shed light on the future design of work.[23] New Work is not a concept that can be introduced or a method[24] that can be applied, but a movement consisting of various individually integrated approaches to solutions.[25]

Currently, the following findings, among others, contribute to the current state of research on New Work.

Digitalization is changing the means of work, the ways of working, communication, and networking.[26] Even a brief glimpse reveals its complexity: Smarter ways of working, constant accessibility, work intensification, increasing personal responsibility, mobility as well as time and location sovereignty, and new tools that make it possible to work and communicate differently across time and space.[27]

Based on the results of numerous studies, overarching principles and areas of design can be identified, demonstrating how New Work should be designed to be attractive to an employer on the one hand and offer employees optimal working conditions on the other.

The principles include individuality, meaningfulness, flexibility, and the dissolution of boundaries.[28]

[20] Cf. Fichtner-Rosada, S.; Hermeier, B. ; Heupel, T., Arbeitswelten, 2019), p. 391.
[21] Cf. Lutze, M.; Schaller, P. D.; Wütherich, H. A., New Work, 2019, p. 358.
[22] Cf. Schnell, A.; Schnell, N., New Work, 2019, p. 7.
[23] Cf. Fichtner-Rosada, S.; Hermeier, B. ; Heupel, T., Arbeitswelten, 2019, p. 392.
[24] Cf. Ternès, A.; Wilke, C., Digitalization, 2018, p. 23.
[25] Cf. Binner, H. F., Megatrends, 2013, p. 366 and Cf. Beltman, S.; van Diermen, O., new ways of working, 2016, p. 274.
[26] Cf. Cloots, A.; Wörwag, S., Zukunft Arbeit, 2018, p. 4.
[27] Cf. Antoni, C.; Ellwart, T.; Kluge, A., Digitalization, 2020, p. 2.; Cf. Fortmann, H.R.; Kolocek, B., Arbeitswelt der Zukunft, 2018, p. 6.; Cf. Fichtner-Rosada, S.; Hermeier, B. ; Heupel, T. , Arbeitswelten, 2019, p. 314; Cf. Mainka-Riedel, M., Stress Management, 2013, p. 5.
[28] Cf. Haubrock, A., Digitalisierung, 2019, p.99; Cf.Fortmann, H.R.; Kolocek, B. , Arbeitswelt der Zukunft, 2018, p. 428 and Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. 72.

Different areas of work can be designed according to the principles of New Work.[29] These include working hours, work location, work content, organization, management, and technology.[30]
It is also essential to note that the design areas are interconnected and influence each other.

3 Methodology

A qualitative empirical social research method has been used to answer the research question to investigate individual requirements and opinions as well as to understand the individual context, drivers, and motivation of the requirements. Further, based on individual impressions, a true-to-life evaluation can be ensured. Thus the target is to derive overarchiving patterns and develop indications how and why New Work shall be designed as a guidance for SMEs and managers. Guided semi-structured interviews were applied as a common variant.[31] In the interview, interviewees are asked questions and narrative prompts that are presumed to be relevant to the research question based on theoretical presuppositions. There are no guidelines for how interviewees respond to these questions and narrative prompts or to what extent interviewees may stray from the guide in their responses and set their narrative emphases.[32] Individual interviews are used to reconstruct subjective perspectives based on the interviewees' everyday experiences and inductively generate hypotheses.

The interview guide was developed using theoretical knowledge derived from the current literature and based on the research question according to the four-step formula (collect, review, sort, subsume).[33]
In sum, the guide consists of five blocks with 29 questions designed to obtain as much information as possible to answer the research proposal. According to Flick's model, all interview questions were checked to verify meaningfulness, formulation, and structure.[34]

[29] Cf. Bayo-Moriones, A.; Larraza-Kintana, M.; Ollo-Lopez, A., New Work Practices, 2010, p. 219.
[30] Cf. Haubrock, A., Digitalisierung, 2019, p.99; Cf.Fortmann, H.R.; Kolocek, B. , Arbeitswelt der Zukunft, 2018, p. 428 and Cf. Attmer, L.; Baumann, D.; Hackl, B.; Wagner, M., New Work, 2017, p. 72.
[31] Cf. Baur, N.; Blasius, J., empirische Sozialforschung, 2014, p. 53 and Cf. Ziegele, M.,Qualitative Leitfadeninterviews, 2016, p. 221.
[32] Ziegele, M.,Qualitative Leitfadeninterviews, 2016, p. 221.
[33] Cf. Ziegele, M., Qualitative Leitfadeninterviews, 2016, p. 222.
[34] Cf. Flick, U., Qualitative Sozialforschung, 2021, p. 222.

The sample was selected considering several criteria: generation, gender, and hierarchical level. In total, eight individuals were interviewed. No prior knowledge of the subject of New Work was required; the interview and the answers to the questions resulted from personal work and life experience.

This study is subject to certain limitations. The results are not representative due to the qualitative method. Similarly, the video interview format due to the COVID-19 pandemic could have influenced respondents' behavior and answers. A further limitation arises from the omission of legislation and legal requirements.

4 Data collection and evaluation

In preparation for data collection, two pretests were conducted using non-sample subjects. The pretest is a test run of the interview that precedes the actual interview.[35] The test phase helps to optimize the wording and provides additional background information. Due to the COVID-19 pandemic, interviews were conducted by video call after the respective consent forms were approved for data use and privacy. Immediately after the interview, the interview recording was transcribed using transcription software. The transcripts were anonymized, ensuring that no conclusions could be drawn concerning individuals. The transcribed interview results were evaluated based on qualitative content analysis according to Mayring and Kuckartz.[36] A category system for coding and assessing the data was developed inductively based on the theoretical framework, the research question, and the data material. The text was subsequently coded using these categories and MAXQDA software.

Table 1 summarizes the categories that emerged based on coding. The categories allow the investigation results to be summarized in a structured way.

From the opportunities versus risks survey on digitalization, it can be deduced that the focus is on opportunities, primarily greater flexibility, more individualized design, networking, and more efficient working methods. The risks include constant

[35] Cf. Baur, N.; Blasius, J., empirische Sozialforschung, 2014, p. 299.
[36]Cf. Buber, R.; Holzmüller, H., Qualitative Marktforschung, 2009, p. 673 and Cf. Kuckartz, U., Qualitative Inhaltsanalyse, 2018, p. 32.

accessibility, difficult demarcation, information overload, a decline in social exchange, and hacking incidents.

The importance of work can be derived from the respondents' motives. In addition to renumeration to secure one's livelihood, the most significant reasons are meaningful work, interpersonal relationships, teamwork, and self-fulfillment. These motives underscore the New Work idea and indicate that the basis can be expanded.

Table 1: Categorization of the test results

Category	Subcategory
Digitalization of the working world	Opportunities
	Risks
Importance of work	Motives & motivating factors
New Work principles	Sense of purpose
	Individuality
	Flexibility
	Dissolution of boundaries
Design areas	Working time
	Work location
	Work-life balance
	Organization
	Leadership
	Technologies & Tools

Studies on principles and requirements were investigated to demonstrate that they align with the theoretical framework and determine whether the interviewees wish to see different forms of the individual tenets. Precise requirements emerged for meaningfulness, individuality, and flexibility.

Meaningfulness was discussed as an essential requirement for the activity. The respondents experience meaningfulness at four levels: Social contribution, personal identification and conviction with the job, identification with the corporate vision, and purposeful and result-oriented tasks. The respondents compare the principle of individuality with self-determined and self-actualizing work. They consider a culture of trust and error necessary as a basis for this. From the survey results, it is possible

to derive three areas that enable individual work: Participation, freedom of decision, and design freedom.

Flexibility is primarily associated with flexible working hours and a flexible arrangement of personal and professional needs. In addition to the time factor, freedom in the choice of work location is also counted as flexibility.

The principle of the dissolution of boundaries, the increasingly blurred boundary between professional and private life, proved challenging. Although flexibility is desired, the respondents perceive the blurring of limitations to be the most significant risk. Ideas on how improved demarcation can succeed or be supported are less concrete.

Potential New Work design approaches emerged via an investigation of individual design areas. The desire for flexible working hours is undisputed. However, there are two interpretations of this: flexible working times within a predefined framework and the dissolution of working time regulations.

Regarding the work location, the desire for a hybrid model (workplace in the company and home office (HO)) is undisputed among all respondents. A potential challenge with a hybrid model is increased difficulty holding meetings with workers in different settings. When working on-site at a company, employees value having single offices and meeting rooms for teamwork and a "tech zone" that offers professional IT equipment. In addition, two concepts, "coworking spaces" and "activity-based working," were briefly presented to the respondents, who were asked for their impressions. The respondents had little or no experience with either concept and little imagination for individual wishes.

To support work-life balance, respondents desire more significant consideration given to individual perspectives. Further requirements are mobile working, more spontaneous vacation decisions, and better meeting organization regarding the right participants and time management. In addition, a digital tool for coordinating workload and additional strategies for shaping work-life balance is desirable.

The fundamental prerequisite for work content is a sense of purpose, which should be provided by purpose-bound and result-oriented tasks and an individual value contribution. In addition, the desire for further training opportunities and the idea of a company-wide task pool (pull principle).

In the area of organization, it can be summarized that the respondents advocate diminishing hierarchies in favor of more dynamic structures and more interactive cooperation and networking at all levels. Employees wish to work quickly, flexibly, agilely, and efficiently and make decisions to streamline decision-making processes. Leaders are expected to have an adaptive and results-oriented leadership style. The leader should fulfill the functions of a mediator of internal political issues, a coach, and a motivator.

In the area of technologies and tools, the study indicates that the focus is initially on standard applications. There is little active or proactive insight into the technologies, digital tools, or applications (of the future) that employees desire to support their work.

Comparing the results of the principles and design areas demonstrates that the contents and requirements are congruent. This congruence confirms and clarifies the interdependencies of the individual dimensions.

5 Recommendations for action

Based on the survey results, Figure 1 lists several recommendations for respective design areas using the principles of New Work. The figure uses the individual design areas and instruments to illustrate the multidimensionality of New Work and the mutual influences of the individual elements. It is crucial to note that the different ideas can be implemented with varying speed or ease and are subject to change of variable intensity. In addition, individual instruments may have greater significance or impact than other measures. Hence, the company must determine its priority.

The changes extend to the entire company, affecting working methods, processes, structures, and employees. Therefore, managers should refrain from implementing only individual instruments, as these have no impact in the sense of New Work.

However, it is recommended to strive for changes according to the four New Work principles and consider potential interactions to act according to the New Work approach. Another recommendation is to make proposals as open as possible so that employees can select each supporting measure individually. Voluntary access makes it possible to incorporate different employee perspectives and, as a company, to determine what employees ultimately use. In addition, leaders should consider that some employees do not prefer flexibility, favoring a stricter prescribed framework. Managers must identify these individuals and support them closely.

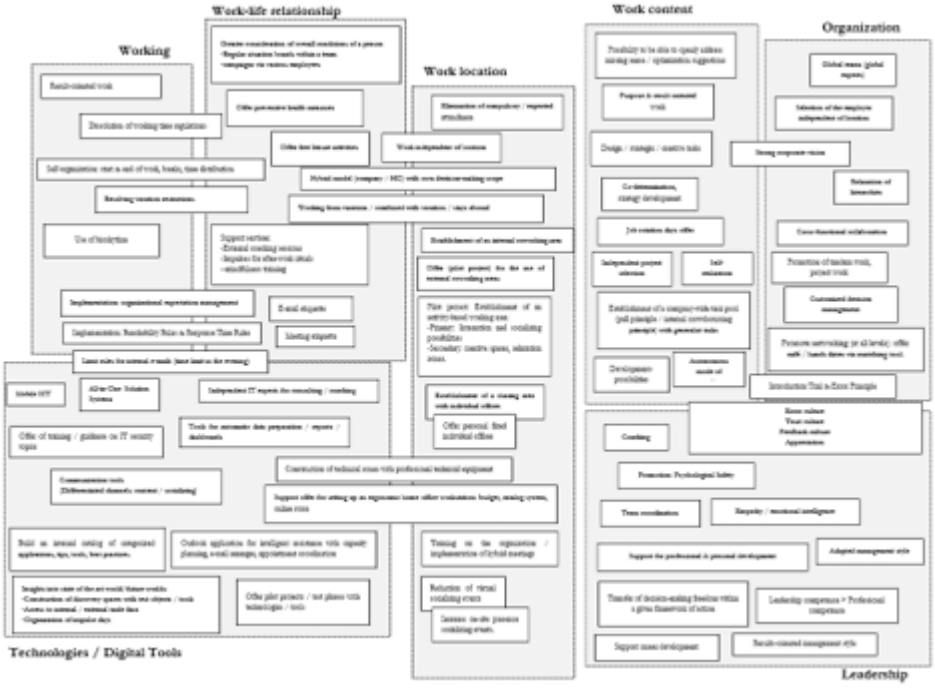


Figure 1: New Work recommendations for action

6 Change management

Another critical aspect that must be emphasized is that New Work is not an implementable project. New Work thrives on continuous change in which the focus is on individuals in the sense of a human way of working.

The greatest challenge is not to adhere to old structures and patterns in new work approaches. It is a matter of breaking away from them and creating space for new ideas to be experienced fully. Depending on the company's size, it could make sense to redesign areas in line with New Work.

7 Conclusion

The world of work is undergoing continuous change. Digitalization, in particular, is currently considered the biggest driver of change in the world of work. As a result of this change, new challenges and opportunities arise for work design. As a company's essential resource, individuals are exposed to unique circumstances, with the desire for more human forms of work design taking center stage. In this context, New Work is seen as a reaction to the increasingly dynamic, changing world of work.

Therefore, this study investigated the requirements for companies to design New Work strategies from the perspective of employees against the backdrop of digitalization. Guided interviews were employed to derive recommendations for action by companies.

At the outset, it can be noted that the COVID-19 pandemic accelerated transformational thinking and probably fostered a new openness regarding these issues. The study enabled a comparison of the theoretical dimensions of New Work with the wishes of employees, whereby the desire for meaningfulness, flexibility, individualization and the dissolution of boundaries can be ultimately confirmed. The desire for an adapted work structure and change in the sense of New Work is presented to clarify that New Work can be seen as a suitable approach to meeting the needs of employees. Requirements and patterns were identified across various principles and design areas. The overriding conclusion is that employees across all types of work desire a wide range of freedoms within a particular framework. Based on the study results, company recommendations for action were developed to address the research question further. A critical success factor is the understanding that New Work thrives on a holistic approach that focuses on people. Only if old structures are dissolved can the new world of work be given room to succeed for companies and employees.

8 Outlook

The work results can serve as a starting point for developing strategies around New Work and work design transformation for companies. In addition, the results can be used for further research using more extensive samples or detailed studies of individual principles or design areas. In particular, further research into the design area of work-life balance, and potential approaches for employees to more easily differentiate between them, is recommended.

In principle, it is advisable to investigate further the qualitative research results obtained using quantitative methods.

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VALUE-INFORMED INNOVATION: INTEGRATING VALUE-SENSITIVE DESIGN AND EVIDENCE-INFORMED PRACTICE IN EDUCATION

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Abstract Digital innovation in education – as in any other sector – is not only about developing and implementing novel ideas, but also about having these ideas effectively used as well as widely accepted and adopted, so that many students can benefit from innovations improving education. Effectiveness, transferability and scalability cannot be added afterwards; it must be integrated from the start in the design, development and implementation processes, as is proposed in the movement towards evidence-informed practice (EIP). The impact an educational innovation has on the values of various stakeholders is often overlooked. Value Sensitive Design (VSD) is an approach to integrate values in technological design. In this paper we discuss how EIP and VSD may be combined into an integrated approach to digital innovation in education, which we call *value-informed innovation*. This approach not only considers educational effectiveness, but also incorporates the innovation's impact on human values, its scalability and transferability to other contexts. We illustrate the integrated approach with an example case of an educational innovation involving digital peer feedback.

Keywords: digital innovation in education, value-sensitive design, evidence-informed practice.

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1 Introduction

Digital innovation in education – as in any other sector – is not only about developing and implementing novel ideas, but also about having these ideas effectively used as well as widely accepted and adopted so that many students can benefit from innovations improving education. However, especially in pressing circumstances such as a lockdown, there is a considerable risk of introducing ad hoc innovations that do not deliver the expected effect or, even if they do, are not scalable or transferable to other contexts.

Effectiveness, transferability and scalability cannot be added after an innovation has been designed, developed or implemented in educational practice. Instead, it must be integrated in the design, development and implementation processes and from the start be an integral part of innovation development. Evidence-informed practice (EIP) has the potential to facilitate this integration. EIP aims to achieve greater effectiveness as well as scalability and transferability of educational innovations by making use of three types of evidence when generating educational innovations: 1) evidence from scientific research, 2) evidence from practical expertise and experience, and 3) evidence from local (system) data (Brown & Malin, 2022). Engagement of others during the design process is also promoted by Froyd et al. (2017), who argue that a *propagation* approach, encompassing the early engagement of stakeholders and potential future adopters, has more chance of successfully transferring effective educational innovations to other contexts than a dissemination approach.

A very relevant, but often overlooked, aspect in the adoption of educational innovations is the impact an innovation has on the personal values of the various stakeholders. Values in educational innovation have received increasing attention in society with the emergence of various examples of unrest generated by digital innovations. An example is the ongoing discussion about the use of online proctoring software (Appelman et al., 2021; Ebbinghaus & Bös, 2020; Harwell, 2020; Scienceguide, 2022; Singer & Krolik, 2021). The importance of values is subscribed by Cukurova et al. (2019) who propose to include the perspectives and values of users as a fourth type of evidence in educational innovation. However, in what way the value perspective can be incorporated in EIP is not explicitly discussed by Cukurova et al. (2019), and this is lacking from other EIP literature as well.

Value Sensitive Design (VSD) is an approach to integrate values in technological design. VSD originates from the fields of information systems design and human-computer interaction (Friedman et al., 2006). It is characterized by engaging both direct and indirect stakeholders in assessing the impact a new design may have on their values, such as autonomy, trust, responsibility, safety or wellbeing, and what design choices will generate the most positive impact. Applying VSD to the topic of online proctoring software, for instance, generated 21 additional implementation criteria to the criteria that were derived from a functional investigation including test runs with the software (van Steenbergen & van der Spoel, 2021).

In this paper we discuss how EIP and VSD may be combined into a integrated approach to digital educational innovations, which we call *value-informed innovation*, that not only considers educational effectiveness, but also takes into account the innovation's impact on human values, its scalability and its transferability to other contexts.

In the next section we discuss the theoretical background of VSD and EIP separately. In Section 3 we combine the two by incorporating values in EIP, using the ADDIE model to structure activities taken from VSD. We illustrate the integrated approach in Section 4 with the example of an educational innovation involving peer feedback and conclude with discussion and conclusions in Section 5.

2 Theoretical Framework

2.1 Value Sensitive Design

Value Sensitive Design (VSD) is "*a theoretically grounded approach to technology design that takes human values into account in a principled and comprehensive way throughout the design process*" (Friedman et al., 2006, p. 349). Human value is defined in VSD as "*what is important for people in their lives, with a focus on ethics and morality*" (Friedman & Hendry, 2019, p. 4). VSD goes beyond instrumental aspects such as functionality, reliability and ease of use, integrating potential impact on moral values of individuals, groups and societies in the design process. VSD distinguishes four types of stakeholders whose values must be taken into account: the sponsor of the new design, the project team doing the design, the envisioned users of the design, called direct stakeholders,

and persons or groups that may be affected by the design though they do not use it themselves, called indirect stakeholders. Especially identifying potential impact on the values of indirect stakeholders requires careful and creative thinking. It requires going beyond the intended use of the design and consider what might happen when use of a design continues far into the future (time perspective) or is spread to other, possibly unintended, contexts (pervasiveness perspective).

The values of all stakeholders, as well as possible tensions between those values, are examined iteratively in what VSD calls a conceptual, empirical and technical investigation. At a conceptual level, the relevant stakeholders and values are identified and defined based on existing literature and knowledge. At an empirical level, the perception of these values by the different types of stakeholders is studied by means of methods such as interviews, focus groups or experiments, leading to the elaboration of the values into norms. At a technical level, values and norms are translated into technical design. VSD has been applied to a variety of technological designs, such as wind parks (Oosterlaken, 2015), browsers (Friedman et al., 2002), educational apps (van der Stappen & van Steenbergen, 2020) and social robots (Smakman et al., 2021).

2.2 Evidence-Informed Practice in Education

Inspired by a trend in the health and social work professions, the attention for using evidence to inform educational practice has attracted increasing attention in the last decade or so (Nelson & Campbell, 2017; Nevo & Slonim-Nevo, 2011). Moving away from a (deterministic) step-wise approach usually denoted by evidence-*based* practice, the term evidence-informed practice (EIP) has become common in the field to describe the utilization of knowledge (evidence) by educational professionals to improve their practice (Brown & Malin, 2022; Nevo & Slonim-Nevo, 2011).

According to Brown and Malin (2022, p. 2), EIP can be described as *'fostering situations in which teaching practice is deliberately informed by knowledge such as: (1) formal research; (2) evidence produced by practitioners' inquiries; and/or (3) evidence derived from school- or system-level data (e.g., student assessment data)'*. Another definition of EIP is posed by Nelson and Campbell (2017, p. 129)*: 'EIP must be seen as the integration of professional judgement, system-level data, classroom data and research evidence.'* In both definitions, the

same three types of evidence – on which we elaborate in the next section – are mentioned that should be incorporated in the improvement of teaching practice.

Educational professionals may have different goals to work in an evidence-informed way. On the most basic level, using evidence to inform the process of implementing an educational innovation will increase the chance of being successful because the decisions made will be sound and grounded in knowledge. If in addition a validated process model such as the ADDIE approach (Branch, 2009) is used, the probability of making the right decisions in the right order will increase further. On a higher level of ambition, working in an evidence-informed way will help to extend the knowledge base by allowing for and facilitation of the vertical spread of the innovation (scaling up) and/or horizontal spread of the innovation (transfer to different contexts).

2.3 Types of Evidence in EIP

As mentioned above, according to Brown and Malin (2022), three types of evidence should be utilized by educational professionals: 1) formal research, or scientific evidence, 2) practical expertise, or practice-based evidence, and 3) (school) system data, or local evidence.

Scientific evidence

Scientific evidence relates to knowledge about 'what works and why' based on theories developed through formal research. Brown et al. (2017) describe research-informed teaching practice (RITP) as teaching practice being informed by practitioner expertise as well as external., peer-reviewed research published by academic researchers. Examples are (systematic) literature reviews, empirical (lab) studies, qualitative studies and meta / effect studies. Scientific evidence is sourced from theory and literature.

Practice-based evidence

Practice-based evidence has been developed through practice-based research, describes 'what works where and for whom' and indicates success factors for implementation and contextual barriers and facilitators. Ideally , this type of evidence is transferable and generic in order to be informative in a different context, and for the outcomes to be scaled up to support a broader field of application (Andriessen, 2016). Examples are co-design-based studies, (didactical) usability studies, prototyping, and good or best practice descriptions (Prinsen & van der Stappen, 2021). Practice-based evidence is sourced from implementation contexts other than the one in which the innovation is developed.

Local evidence

Local evidence is knowledge obtained by systematically analysing multiple existing data sources within the school to describe 'what happens in our school'. These data sources can be both quantitative and qualitative, e.g., student characteristics, achievement data, classroom observations and system log files of learning management systems (LMSs) (Brown et al., 2017). Applying this evidence to innovate educational practice as well as to evaluate such innovations is called data-based decision making (Schildkamp & Kuiper, 2010). Local evidence is sourced from the specific implementation context in which the innovation is developed.

2.4 Propagation of Educational Innovations

EIP is the combined usage of local, practice-based and scientific evidence (Brown et al., 2017; Nelson & Campbell, 2017; Nevo & Slonim-Nevo, 2011). This combination of perspectives can be considered as 'triangulation of evidence' to improve practice and has the potential to contribute to the propagation of innovations. We consider the propagation of innovations as the stimulation and facilitation of both vertical spread (*scalability*) and horizontal spread (*transferability*) of improvements to teaching and learning (Brown & Malin, 2022).

Froyd et al. (2017) argue that a propagation paradigm towards educational innovation is paramount to eventually achieve system-wide adoption of an innovation. This propagation paradigm has an equal emphasis on both fit and

efficacy of the educational innovation being developed. Early stakeholder engagement including stakeholders from a diverse set of contexts is central to the approach, as is learning how the innovation should be implemented best through engaging with potential users and adopters.

To fit an innovation effectively to the implementation context – and to ultimately reach adoption of the innovation – it is crucial that the innovation in question does not harm the values of direct and indirect stakeholders related to that context. If negative consequences of the innovation have impact on (intended) users and adopters, the remedy might be worse than the ailment. Indeed, Davies (1999, p. 115) already stated more than 30 years ago that consideration of values is paramount: *»Evidence is also required about ethical issues of educational [or care] practice, such as whether or not it is right or warrantable to undertake a particular educational activity [or health care intervention].»*

Since then, many perspectives and approaches towards the utilization of evidence in professional practice have been proposed, but ethical issues have largely been underexposed. Recently, Cukurova et al. (2019) emphasized the use of four sources of information, in which the first three types of evidence are the ones mentioned above, whereas the fourth type of evidence is »*the perspectives and values of those people who are directly or indirectly affected*« (Cukurova et al., 2019, p. 5). What is currently missing however, are insights into how to incorporate values of direct and indirect stakeholders into the implementation of educational innovations.

2.5 Relation to other approaches combining research and practice

Several approaches exist that also combine research and practice and share similar underlying principles with EIP, such as Design Science Research (Hevner et al., 2004), Action Research (Babüroglu & Ravn, 1992; Baskerville & Wood-Harper, 1998) and Action Design Research (Sein et al., 2011). However, these research approaches all combine rigor and relevance towards the goal of theory advancement by e.g., incorporating practice and real-world usage into the research process. EIP, and our proposed approach, have the aim of incorporating existing knowledge into the work process of (educational) professionals, but not the goal of generating new knowledge.

3 Incorporating Values in Evidence-Informed Practice

A widely adopted systematic approach to instructional design and educational innovation is ADDIE (Branch, 2009), which comprises five phases from where the acronym originates: Analyze, Design, Develop, Implement and Evaluate. In all phases of this methodic approach, we can utilize the different types of evidence as described in Section 2.3. In Figure 1, we illustrate how we can incoporate practice-based evidence sourced from other implementation contexts (left), local evidence sourced from the specific implementation context in which we are running through the five ADDIE phases (center), and scientific evidence sourced from theory and literature (right).

Since the ADDIE approach was introduced, more agile and iterative approaches have been adopted in many professional domains concerned with design – starting from software engineering – as well as in education. It is possible to incorporate such short-cycled iterations within the ADDIE approach, as is depicted by the smaller cycle positioned behind the three phases Design, Develop and Implement. The process starts with Analyze, subsequently running through Design, Develop and Implement in several iteration cycles, and rounding off with Evaluate. Partial, focused evaluations will be conducted within each of these iterations to guide the planning of the next iteration. In the final Evaluation phase, the innovation process is evaluated in an integral manner.

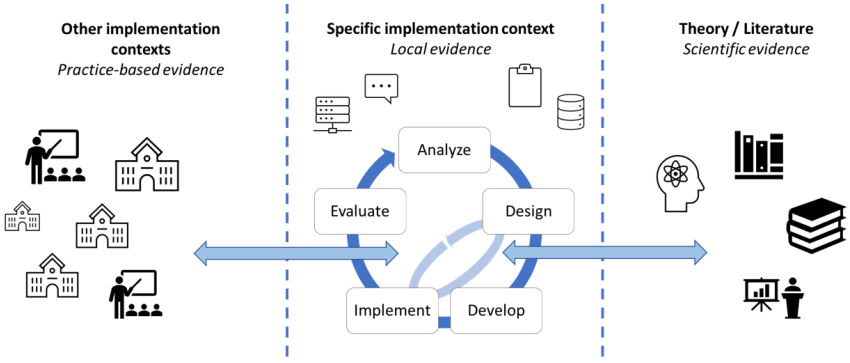


Figure 1: Utilizing different types of evidence in EIP within the ADDIE approach

VSD adds the perspective of moral impact to the aims of effectiveness, transferability and scalability. As VSD is strongly based on stakeholder engagement, it also aligns well with the propagation paradigm as proposed by Froyd et al. (2017). It enriches conversations with practitioners by introducing the topic of personal values and widens the scope of conversational partners by explicitly including persons or groups that do not directly engage with the educational innovation but are nevertheless impacted by it (e.g., housemates of students when using online proctoring software). In Figure 2, we illustrate which VSD-activities can be undertaken to elicit *value-based evidence* from all three sources of evidence: other implementation contexts, the specific implementation context in question, as well as from literature.

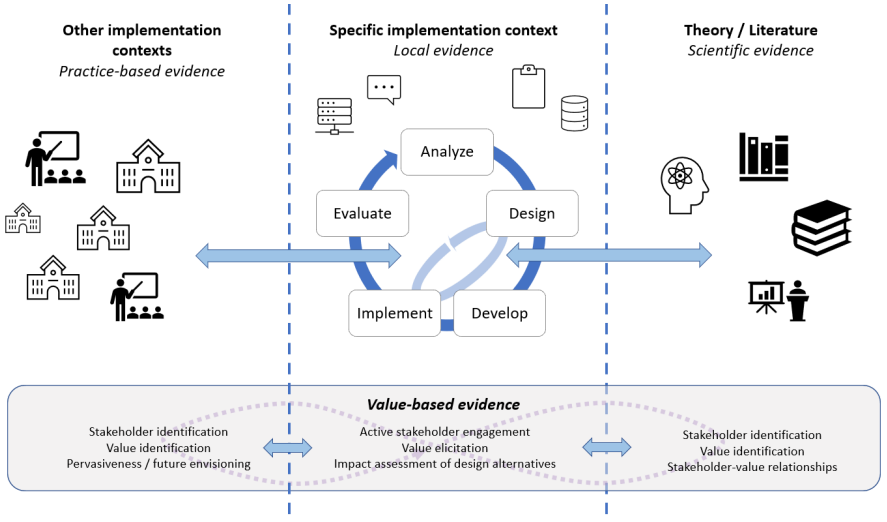


Figure 2: Combining VSD with EIP

VSD adds another focus of investigation: human values. What values to take into account in what manner, is based on academic literature (conceptual investigation), as well as practice-based knowledge (conceptual and empirical investigation) and local data (technical investigation). Typical VSD activities that are added are stakeholder indentification, value identification, pervasiveness/future envisioning, active stakeholder engagement, value elicitation and impact assessment of design alternatives. How these activities may take shape in the ADDIE phases is illustrated in the next section.

4 Worked Example of the Integrated Approach

To illustrate how the integration of VSD in EIP might work, we walk through an hypothetical example process of introducing digitally supported peer feedback. This example case is one where for a specific course, a team of educators consider the introduction of peer feedback. The reasons for considering peer feedback are that the teachers are experiencing a high workload, many students are failing the course and students have consistently been asking for more and more timely feedback on their work. The hope is that allowing students to provide feedback on each other's work digitally will have a positive impact on all of these issues simultaneously.

Table 1: Examples of the utilization of various types of evidence in the process of implementing an educational innovation

	Local evidence	Practice-based evidence	Scientific evidence	Value-based evidence
Analyze	Check assumptions: - assess teacher workload in objective quantities related to teacher activities - describe quantity and timing of received feedback - analyse students' performance and engagement during the course	Inquire about good – and bad – practices of the application of peer feedback and the observed results Request expert feedback on the problem analysis	Check literature for evidence on peer feedback, e.g. - To what extent does it lower teacher workload? - What does it require from students to be deployed successfully?	Check literature for identification of stakeholders and values in relation to peer review Identify potential value tensions in using peer feedback Apply time and pervasiveness perspectives to the envisioned peer feedback
Design	Compare alternative existing configurations / administrations from the peer feedback system	Brainstorm with colleagues and experts on redesign of course with peer feedback integrated within local constraints	- State intended goals of the innovation based on scientific insights on the added value and effectiveness of peer feedback - Collect generic constraints on the application of peer feedback	Elicit value norms and priorities relating to peer feedback from the stakeholders (dialogue with e.g., students, teachers, (board of) examiners, IT support, etc.). Investigate variations of peer feedback with stakeholders on how these affect their values (impact assessment), e.g. by - Interviewing - Focus groups - Value scenario's - Mockup/prototype evaluation - Harms & Benefits mindmap - Ethical matrix Relate value threats and tensions to design choices
Develop	Prepare the chosen configuration in such a way that data can be collected in future phases	Solicit advice from experts/colleagues on how to incorporate peer feedback in local context (course/systems)	Follow guidelines from literature for successful implementation of peer feedback (scripting)	Relate values and norms to peer feedback configuration choices
Implement	Perform pilot walkthrough(s) of the configured peer feedback system before going live	Request technical and pedagogical support in configuration of peer feedback system (regarding e.g. effectiveness & efficiency)	Use the scripting guidelines when configuring the system and syllabus	Relate values and norms to peer feedback implementation choices
Evaluate	Evaluate engagement with the LMS / peer feedback system and student achievement (grades)	Gather experiences of involved students and teachers, e.g., what did they consider beneficial, what should be improved?	Use validated instruments to measure effectiveness of the innovation and implementation	Evaluate impact of peer feedback on (direct and indirect) stakeholders

In Table 1, we illustrate for this example case how the four types of evidence are iteratively collected and VSD is integrated in the process. During the *Analyze* phase, the envisioned problem is analysed by using local data, experience of practitioners with peer feedback and academic literature on peer feedback, not only to gain insight on workload, feedback quality and student performance (EIP), but also on moral

impact (VSD). To assess moral impact, an inventory is made of persons or groups that might be impacted by the introduction of peer feedback and what character that impact might have (e.g., positive impact on wellbeing of teachers because of less workload and on confidence of students because of additional learning opportunities, but maybe negative impact on assurance or privacy of students). In the *Design* phase, besides studying existing configurations and effectiveness of alternative configurations (EIP), stakeholders (teachers and students, but also examiners) are actively engaged and asked about how they experience alternative configurations (VSD), using techniques such as interviews, focus groups or experiments. In the *Develop*, *Implement* and *Evaluate* phases, evidence from data, practice and literature are used to assess alternatives and achieve not only an effective, transferable and scalable solution (EIP), but also a solution that respects human values (VSD).

6 Conclusion and Discussion

In this paper, we propose to integrate value-sensitive design with evidence-informed practice as a way to not only ensure effectiveness, transferability and scalability of educational innovations, but also a positive moral impact. Value-informed innovation extends evidence-informed practice with methods and techniques to actively take human values into account in the design process of educational innovations. Aligning well with a propagation approach, value-informed innovation extends the types of stakeholders to involve with relevant non-users and future users and it extends the topics to be discussed with human values.

The integration of VSD in EIP operationalizes what Cukurova et al. (2019) propose as a fourth type of evidence, besides scientific evidence ('what works why'), practice-based evidence ('what works where and for whom') and local evidence ('what happens in our school'): the perspectives and values of those people who are directly or indirectly affected. This, what we call value-based evidence, describes 'what is considered valuable by whom', relating implementations to human values of direct and indirect stakeholders.

Value-based evidence originates both from academic science (conceptual investigation) and practice (empirical and technical investigation). It appears that, though values are rightly considered a fourth type of evidence, value-based evidence is of a different order than the three others. Unlike scientific, practice-based and local evidence, value-based evidence can be sourced from all evidence sources: it can be derived from scientific literature, by elicitation from stakeholders in other contexts, and derived from local data and experience. Moreover, value-based evidence can (and should) be gathered from contexts in which implementation is not intended (yet) by incorporating the time and pervasiveness perspectives.

Our work is a conceptual and theoretical contribution on the integration of EIP and VSD to incorporate human values in the innovation process in educational practice. For future work, it would be interesting to test this proposed approach in real-life innovation projects, with the aim of concretizing the approach, to develop practical insights and guidelines and to evaluate and improve the ideas presented in this paper. Finally, we expect VSD can be integrated in a similar way in professional domains other than education with approaches that resemble EIP.

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Media Choice in the Digital Era: A Replication Study Using Digital Traces

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Abstract In recent years, the use of communication and collaboration media tools has increased manifold due to a rise in spatially distributed work. Which media tools individuals choose for their communication activities has been a research question of lasting interest. Established research focused on traditional media, for example, face-to-face, phone, or email. Moving the focus from traditional media towards digital tools requires rethinking previous findings. It is unclear whether the factors influencing digital tools' choice changed or stayed the same. This paper replicates if the traditional hypothesized relationships and constructs of media choice still hold in the digital era. In response to a surge in interest, digital traces—activity logs from routine technology use—are analyzed for conceptual replication. The conceptual replication revises the boundary conditions of established media choice theory and shows that the supervisor remains a positive influence, whereas physical location becomes negligible, and the coworkers' influence is inconclusive.

Keywords: media choice, replication, digital traces, digital tools, collaboration.

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1 Introduction

The COVID-19 pandemic has led to an unprecedented wave of working from home and spatially distributed knowledge work (Mattern et al. 2021; Wageman et al. 2012). Distributed workers rely on communication media that enable them to collaborate at a physical distance (Bélanger and Watson-Manheim 2006). In recent years, the availability of communication and collaboration media tools has increased manifold (Statista 2019). When, how, and what media to choose is challenging for employees and requires coordination with coworkers for aligning their joint media use (Chudoba et al. 2005; Karr-Wisniewski and Lu 2010; O'Leary et al. 2014). Insufficient coordination negatively affects performance because non-alignment leads to non-effective media use and collaboration (Watson-Manheim and Bélanger 2007). As a result, effective coordination of joint media use and succesful collaboration requires understanding media choice (Stephens 2007; Watson-Manheim and Bélanger 2007).

Media choice depends on the physical location of employees, social factors such as supervisor and coworkers, and the communication purpose (Riemer 2009). Previous research into media choice focused on traditional media, for example, face-to-face, phone, chat, email, or paper documents (Woerner et al. 2004). However, using digital media tools gains momentum due to more distributed work (Wageman et al. 2012) and a growing collaboration software market, diversifying the tools available in an organization (Gartner 2019). Moving the focus from traditional media towards digital tools requires rethinking previous research. It is unclear whether the factors influencing digital tools' choice changed or stayed the same over the last decade compared to established media choice. This paper replicates if the traditional hypothesized relationships and constructs of media choice still hold in the digital era, posing the question: **How do supervisors, coworkers, and physical location influence media choice in distributed work?**

Addressing this research question provides evidence for generalizing established theory on media choice to the context of digital work. Media choice theory has been empirically validated multiple times using surveys and interviews. Our conceptual replication allows refining and revising established media choice theory by using digital traces as a novel instrument. Digital traces are activity and interaction data

from routine technology use, which have attracted considerable research interest in recent years (Hüllmann 2019; Hüllmann and Krebber 2020).

2 Background

2.1 Replication and Digital Traces

Replications can increase the robustness of scientific advances by providing more evidence for or against a research finding or by determining the boundary conditions of existing theory (Dennis and Valacich 2014). Although exact replication strives to replicate the original study as close to the original as possible, replication is "not always a carbon copy of the original study" (Saunders et al. 2017, p. 342). Dennis and Valacich (2014) distinguish three approaches to replication: exact replications, methodological replications, and conceptual replications. Conceptual replications inquire about the same theoretical constructs as the original studies but use varying operationalization, that is, different measures, instruments and methods (Saunders et al. 2017). There have been repeated calls for replications with novel instruments to examine the boundary conditions of original theory (Eden 2002; Tsang and Kwan 1999). Conceptual replications may also bring theory into a new context, extending and clarifying the original propositions (Colquitt and Ireland 2009). Performing conceptual replications is encouraged over other approaches for well-established theory (Tsang and Kwan 1999).

Media choice is an established theory that has been empirically validated multiple times. Our study tests if the media choice theory generalizes to the digital era and the context of digital tools. Digital traces as a novel instrument for replication are used, which allow for robust and original replication studies (Agarwal and Dhar 2014; Mertens and Recker 2020). Digital traces are longitudinal event log data of routine communication and collaboration systems use (Hüllmann 2021). For example, log data from sending or receiving emails, text messages, or sharing files in Microsoft 365 (Hüllmann and Kroll 2018). Digital traces are typically stored in the cloud and can be extracted without end-user interaction, and they can entail the complete history of using a particular collaboration tool. Hence, digital traces promise a more complete and accurate account of past human behaviours than self-reported data such as surveys or interviews (Chaffin et al. 2017; Scharkow 2016).

Therefore, digital traces are robust for testing the media choice theory that was established using surveys and interviews.

2.2 Digital Era of Media Collections and Media Choice

Spatially distributed workers rely on communication tools to collaborate at a physical distance (Bélanger and Watson-Manheim 2006). Usually, these workers do not rely on a single tool to fulfil their tasks but instead use a subset of tools (Lee et al. 2007; Stephens 2007). We call this subset of tools their **media collection**, which the workers choose from a heterogeneous set of tools available in their organization, i.e., the organization's **media landscape**. Making this choice for a media collection depends on social factors such as supervisor and coworkers, theorized as antecedents of media choice. Previous studies on media choice tested these antecedents for traditional media, for example, telephone, mail, email, or face-to-face meetings (Riemer et al. 2009). Conversely, our replication focuses exclusively on digital media tools in distributed work, thereby testing whether media choice holds in the digital era.

The concept of a media collection is derived from the theory of communication media repertoires by Watson-Manheim and Bélanger (2007). Watson-Manheim and Bélanger (2007) group different media collections according to their communication purpose, for example, coordination (i.e., managing interdependent tasks), information sharing (i.e., exchange of knowledge), or relationship development (i.e., socializing into the organization). Other works characterize media collections by their size (i.e., how many tools are included) and how the tools are used (sequentially or concurrently) (Lee et al. 2007). Tools in the media collection may either be synchronous or asynchronous and require colocation of workers or are spatially flexible (Riemer 2009). However, most tools nowadays provide asynchronous communication features such as text, voice, and video messaging—even if they primarily aim at real-time communication, for example, Skype. Thus, by design, digital tools do not require the colocation of the users as they enable distributed work. Another classification scheme considers the type of communication and the features of tools (Fouss and Chang 2000). However, modern tools converge towards multi-purpose integrated systems (Riemer 2009), making classification by features difficult. As distinguishing media collections by features, synchronicity, or colocation is infeasible for integrated systems in distributed work, we replicate the results of

Watson-Manheim and Bélanger (2007) and focus on the communication purpose for distinguishing media collections.

Media choice theory posits that the social factors, actions, and behaviours within workgroups affect a worker's attitude towards communication technologies and the choice of tools (Fulk 1993). Social factors include norms for media use and the imitation of coworkers' media usage (Fulk et al. 1990), perceived media richness, and media experience (Schmitz and Fulk 1991), task experience, and situational factors (Stephens and Davis 2009), as well as organizational factors, such as job role or position in the hierarchy (Stephens 2007). Despite many factors being researched, previous studies find that the attitudes of coworkers and supervisors are the critical social influence for media choice (Treviño et al. 2000; Webster and Treviño 1995). Supervisors exert influence via verbal statements through which workers adopt the supervisors' perceptions of media choice (Schmitz and Fulk 1991). As part of such verbal statements, supervisors may promote their favourite tool (Schmitz and Fulk 1991). Workers may also choose to imitate the supervisor's media choice to ease communication (Fulk et al. 1990). Consequently, we hypothesize: **H1a: The assigned supervisor is positively associated with the choice of media collection in distributed work. H1b: The assigned supervisor's media collection choice is positively associated with the choice of media collection in distributed work.**

In addition to the supervisor, the coworkers shape attitudes towards tools through everyday talk, discussing the benefits and drawbacks of tools and sharing knowledge on how tools are used. More specifically, the coworkers influence how tasks are perceived and the appropriate media choice to solve a task (Schmitz and Fulk 1991). They establish social structures and norms on media use in the organization through routine tool use (Fulk et al. 1990). Coworkers co-learn about the tools and influence each other's perceptions (Fulk et al. 1990), as they must use the same, or at least compatible tools, to communicate. Because of these reasons, we hypothesize: **H2: The coworkers are positively associated with the choice of media collection in distributed work.**

The original theory argues that social influence disseminates via social encounters such as water-cooler chats, ad-hoc meetings, and random encounters. As the physical location constrains how people meet and communicate, it is another critical

factor for media choice (van den Hooff et al. 2005; Treviño et al. 2000; Webster and Treviño 1995). A change in the digital era is the increase of spatially distributed work across multiple sites, characterized by a reliance on digital tools. Traditional media such as face-to-face meetings are less relevant. Since the physical location is less important if the choice is only between digital tools, we hypothesize: **H3: The assigned location is negligibly associated with the choice of media collection in distributed work.**

3 Methods

Our replication draws from a sample of Microsoft 365 digital traces data. The data is collected from an organizational unit of a global systems integrator and managed service provider with 30,000 employees. The selected organizational unit operates across 18 locations in one European country. The unit consists of IT service consultants, who work exclusively with Microsoft 365, drafting and sharing documents, presentations, and excel sheets. There is a policy that Microsoft 365 must be used, and the machines are limited to this software, including Exchange, OneDrive, SharePoint, Teams, and Yammer. Which of these five tools to choose is left to the employee's discretion. The organizational unit is representative for the organization at hand and represents a typical IT service consulting practice. The unit is divided into subunits distributed across locations with various tasks. An excerpt of the data and the underlying data structure is illustrated in Table 1. The sample consists of 813 knowledge workers and contains usage data that is aggregated per month and covers the timespan from June 2018 until January 2019. The usage frequency of each tool is given as the sum of actions performed per tool and per month. For example, accessing files on OneDrive, or sending an email or chat message. Due to the data's sensitive nature, it cannot be shared publicly.

Table 1: Excerpt from data

ID	Exchange	One Drive	Share Point	Yammer	Teams	Org. Subunit	Supervisor ID	Location
891	10,583	32	69	47	0	Operations	1111	Location1
892	10,670	1,524	48	49	0	Operations	891	Location1

As with any statistical model, we have underlying assumptions that manifest in parameter configuration for our pre-processing and data cleansing. Because choosing fixed values for these parameters would be arbitrary, we test multiple parameter configurations for our models that are common in media choice research—as recommended (Mertens and Recker 2020; Schwab et al. 2011). The most central assumption is the minimum usage frequency threshold that determines whether a worker is actively using a particular tool. A tool is included in a media collection only if the worker is actively using it. We test various minimum usage frequency thresholds (40, 110, 250, 500, or 1000 actions per month). Besides the usage frequency threshold, we filter organizational subunits depending on the minimum number of members constituting an organizational subunit. We test the values 0, 5, 10 for minimum unit members. Two data sources for the assigned subunit of each employee were available: active directory, which was entered by human resources, and Microsoft Teams data, which was entered by the employees themselves. Both sources were available in two versions leading to four different configuration parameters. In our subsequent analyses, we test all parameter combinations (5 usage thresholds * 3 minimum members thresholds * 4 subunits = 60 configurations) and report the mean and box plots for the calculated test statistics. All parameter configurations led to similar results.

We use Ward's hierarchical clustering (minimum within-cluster variance criterion) to identify relevant media collections in use (Murtagh and Legendre 2014; Ward 1963). The cluster analysis is based on a table with binary values that indicate for each tool whether an employee is an active user or not (active=1; not active=0). As stated above, the cluster analysis is repeated for the 60 different parameter combinations. As hierarchical clustering requires choosing a fixed number of clusters a priori, we determine the number of clusters by the differences of average within-cluster homogeneity (Thorndike 1953)—commonly referred to as the "elbow method". We identify the frequently used media collections by visually inspecting the dendrograms, elbow plots, and histograms (Figures 2a,b,c in appendix). The resulting media collections are mutually exclusive. We determine the primary communication purpose of a media collection through its included tools. Based on the majority of purposes of the included tools in the media collection, we derive the purpose of the media collection itself (Lee et al. 2007). Based on Schwade and Schubert (2017), we consider Exchange, OneDrive and SharePoint as information sharing tools, whereas Yammer and Teams are relationship development tools.

For replicating the hypotheses, we operationalize the coworkers' influence through the assigned organizational subunit of the worker. The media collections are given as distinct sets of tools. The supervisor is the direct manager, to who the employee reports, and the physical location is the assigned city and street address. All variables are given as nominal IDs. Because all variables are of nominal scale and the factor levels reach up to 119, an unordered multinomial regression would show different factor loadings for each instance and not yield helpful results (McElreath 2020). For example, it would show the results for 119 managers instead of the general influence of the supervisor. Rather, we show the association between the factor variables and test the stochastic independence using Pearson's chi-squared test and Fisher's exact test (with Monte Carlo simulations for the p-values based on Patefield (1981)). Accordingly, posthoc correlation analysis to estimate the effect size is performed with Cramer's V, suited for nominal measurements (Cramér 1946; Sheskin 2000). Our interpretation of effect sizes follows Cohen's remarks on cross-tabulation (Cohen 1988, p. 224; cited via Ellis 2010, p. 41).

4 Results

Exchange is the tool used by all workers in the sample. The median count of actions performed in Exchange over the eight months is 12,363. The next most used tools are SharePoint, OneDrive, and Yammer with median activity between 113 and 263. Teams is not in use by most workers (see Table 2).

Table 2: Descriptive Statistics

Descriptive Statistics							**Factor Levels**	
Tool/ Statistic	N	Mean	St.Dev.	Min.	Median	Max.	Variable	Levels
Exchange	813	16,049	14,635	495	12,363	128,878	Employee	N=813
OneDrive	813	5,627	33,116	0	114	707,030	Org. Subunit	N=10
SharePoint	813	808	1,852	0	263	19,636	Supervisor	N=119
Yammer	813	454	794	0	113	6,155	Location	N=18
Teams	813	19	183	0	0	4,987	MediaCollection	N=8

From Figures 2a-c (appendix), we identify eight clusters because the difference in average within-cluster homogeneity converges to zero after eight clusters. Looking at the eighth cluster in the dendrograms, we merged further "potential" clusters into

a media collection called "Others" because these clusters had adoption rates close to zero. The elbow plot and dendrogram are consistent across all 60 configurations.

Table 3 depicts the identified media collections. The importance of Exchange is emphasized as 262 out of 813 workers use only Exchange. It is part of every frequently used media collection that we identified. Besides Exchange, SharePoint is another popular tool in the media landscape and part of four media collections. Another observation is the recurring absence of Microsoft Teams, which is not extensively used, and, thus, not part of the media collections, except for the "All" collection. Table 3 shows three media collections with an information-sharing focus, three collections with both information sharing and relationship development focus, but no media collection with only a relationship development focus.

Table 3: Media collections with average active users of each collection.

Media Collection	Purpose	N	Mean	St.Dev.	Min.	Median	Max.
Exchange	Information Sharing	60	268.517	154.500	64	262	498
Exchange, OneDrive	Information Sharing	60	91.050	53.181	13	106	148
Exchange, SharePoint	Information Sharing	60	86.733	37.136	33	96	134
Exchange, SharePoint, OneDrive	Information Sharing	60	75.567	27.111	31	88	106
Exchange, SharePoint, OneDrive, Yammer	Both	60	121.917	108.223	6	87	316
Exchange, SharePoint, Yammer	Both	60	58.617	42.346	6	46	116
All	Both	48	18.167	15.833	3	12	46
Others	–	60	75.400	23.290	35	76	108

Figure 1 and Table 4 show the estimated correlations. The results show a high correlation between the supervisor and the choice of media collection, but only a small correlation between the supervisor's own choice of media collection and the worker's choice (cf. Cohen 1988; Ellis 2010). Consequently, the hypothesis on the supervisor's social influence holds (H1a), whereas its particularization in the imitation hypothesis (H1b) does not hold.

Table 4: Cramer's V correlations

Covariate	N	Mean	St.Dev.	Min.	Median	Max.
Supervisor	60	0.467	0.019	0.430	0.476	0.490
Supervisor Collection	60	0.151	0.016	0.127	0.154	0.184
Subunit	60	0.183	0.047	0.129	0.173	0.311
Location	60	0.164	0.021	0.142	0.156	0.205

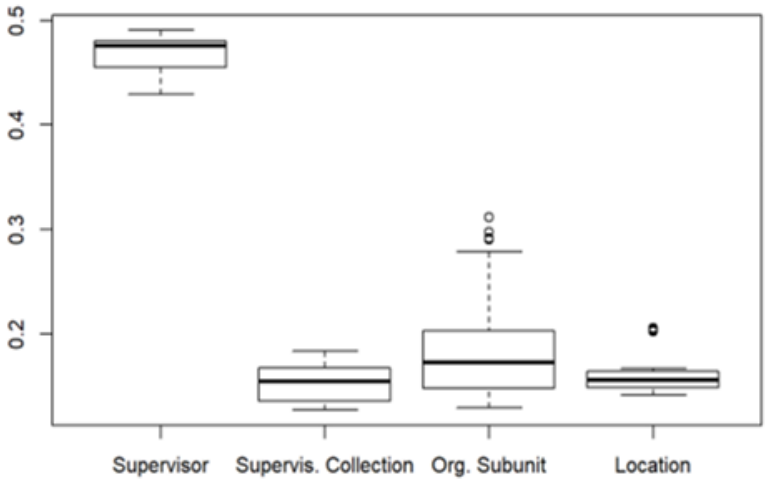


Figure 1: Cramer's V correlations

As coworkers and physical location show a small correlation with the media collection choice, which is lower than the minimum effect size of interest, the hypothesis about the coworkers' social influence does not hold (H2), whereas the negligible association with the physical location does hold (H3). None of the covariate pairs is independent across the tested parameter combinations according to Pearson's Chi-Squared test and Fisher's exact test. In other words, all correlations are statistically significant.

5 Discussion, Implications, Limitations, Future Work

Our results show that Exchange is prevalent in all media collections, supporting Watson-Manheim and Bélanger (2007), who show that email is the most frequently used media tool and is relevant for all communication purposes. We find superior

use of the information sharing collections compared to the relationship development collections, corroborating Watson-Manheim and Bélanger (2007). Explicit relationship development in teams via digital tools is less common, requiring future research in subsequent studies. Lee et al. (2007) find that smaller media collections have more users than larger collections. We also find a tendency towards smaller media collections with "Only Exchange" having the highest active user rate, although the results are not as clear as in Lee et al. (2007). Despite a heterogeneous media landscape (i.e., many different tools being available), the identified media collections clearly show Exchange and SharePoint as the most frequently used tools. Small media collections being favoured implies that explicit management and coordination of media collection choice is not as critical as assumed because there seems to be little coordination overhead. Nevertheless, we only looked at Microsoft 365, and samples with a larger media landscape may yield varying results.

According to Treviño et al. (2000; Webster and Treviño 1995), the supervisors' media behaviours and attitudes influence the media choice of individual workers in distributed work settings through verbal statements as part of conversations, meetings, and collaborative work. The supervisors may also promote specific tools (Schmitz and Fulk 1991). Our results corroborate the association between the assigned supervisor and a worker's media choice. Yet, our results do not substantiate the hypothesis that workers may imitate the media choice of their supervisor for joint communication purposes (Fulk et al. 1990). The supervisor has different tasks than the subordinates and thus may require a different media collection. Except for the imitation aspect, our analysis is agnostic to the specific behaviors of a supervisor that influence the subordinates' media choice. Coworkers establish norms and values surrounding media collections through routine and joint use of tools. They shape the perceived task characteristics and media richness, which Schmitz and Fulk (1991) find to influence the perceptions of appropriate media choice. Our data suggests that the coworkers do not have a clear association with the media choice of distributed workers. Perhaps, the perceived task characteristics and attitudes towards media appropriateness are not sufficiently homogenous within organizational subunits to paint a clear picture. Intra-job differences and a potential lack of widely shared norms on tool use between coworkers may lead to different media collection choices (Treviño et al. 2000). Multiple studies find a relationship between physical location and media choice (van den Hooff et al. 2005; Treviño et al. 2000; Webster and Treviño 1995). The physical location presents a constraint towards

communication, as a high distance prevents face-to-face communication and encourages the use of digital tools. Our analysis shows that the hypothesis of a negligible effect between physical location and media choice holds. The physical location has little effect on media choice in the digital era, as opposed to established theory on media choice. Summarizing, our replication finds evidence in digital traces for the hypotheses that the supervisor has a strong effect and that physical location has a negligible effect on media choice.

Our analysis' limitations include a missing disentanglement of dyadic influences and shared norms on the perceptions of task and media appropriateness (e.g., Stephens and Davis 2009; Webster and Treviño 1995). We only correlate the nominal supervisor and the organizational subunit with the selected media collection. Our results suggest that the influence of coworkers is not as homogenous as expected, i.e., not all coworkers share the same media collection. Potential causes may be a lack of shared norms on tool use or that our analysis misses intra-job differences in the same way as other studies do (e.g., Treviño et al. 2000). For an inquiry into the dyadic social influence of coworkers, digital traces from enterprise social networks may be a future research opportunity (Hüllmann and Kroll 2018). Our study provides a correlational view of the topic of media choice at a time before COVID-19. With the ongoing development of digital collaboration tools, the media landscape is under continuous change, and longitudinal research designs may further elucidate the phenomenon. Our study looks at an idiosyncratic sample that describes a distributed organizational unit from a global services provider. Although Watson-Manheim and Bélanger (2007) show that media collection types persist across two organizations, the identification of media collections is specific to the task structures of the organization. Hence, we expect the nature of the task to influence a worker's choice of a media collection, and our results may not generalize to task structures other than IT service practice. Previous research theorizes other factors to be relevant for media choice that are unavailable in the digital traces of Microsoft 365. For example, individual roles, strategies, and experiences, as well as personal preferences, are theorized to affect media collection choice. Given limitations the available data, we only analyze the influence of supervisor, coworkers, and physical location. Future work can extend the granularity of the digital traces and complement the analysis with interviews or surveys for more insights. The organizational unit under study has an exclusive focus on Microsoft 365. Nevertheless, external communication and collaboration tools that are not part of

the Microsoft 365 suite may be in use by the workers, although such tools are not approved by the organization ("Shadow IT"). These tools are out of the scope of this study and require further data collection. For providing recommendations and best practices on the explicit management and coordination of media use, follow-up research should link performance data to the identified media collections. Elucidating the link between media collections, media choice, and performance will expose levers for managerial interventions geared towards media synchronization and coordination. Since our approach is based on digital traces, caution is required because the analyzed activities in the data set do not necessarily consume the same amount of time, e.g., crafting an email may take longer than downloading a file.

In conclusion, we replicate established theory on media choice using the novel instrument of digital traces and bring the theory into the digital era. In the empirical setting of a global service provider, we identify the frequently used media collections and address the antecedents of media choice in distributed work settings based on analyzing a unique quantitative sample of digital traces. We contribute evidence to media choice research and replicate that information sharing is the primary purpose of media collections. Our analysis partially corroborates the existing theory on collective media choice, showing that the supervisor is associated with an individual worker's media choice, whereas the association with the physical location is negligible. Thus, managers should consider their influence on their employees' media choices. We show that digital traces are a well-suited instrument for conducting conceptual replication studies. Despite the limitations of our data, digital trace research shows prospects for subsequent inquiries and replications, further extending existing research.

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Appendix

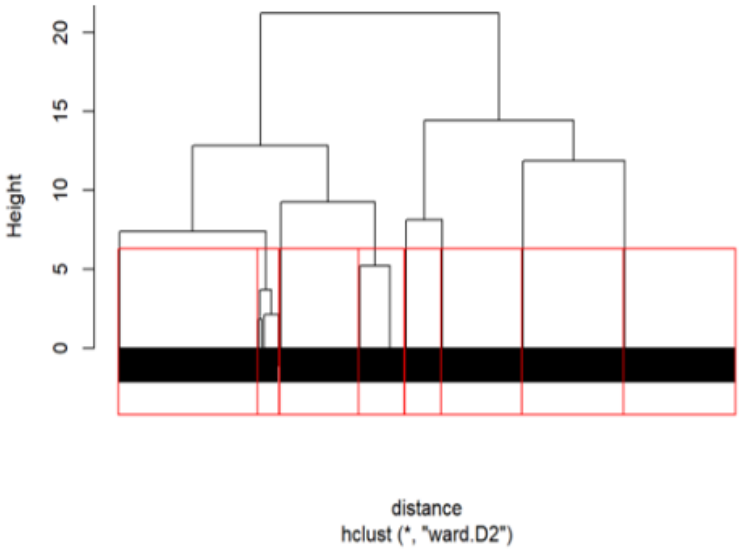


Figure 2a

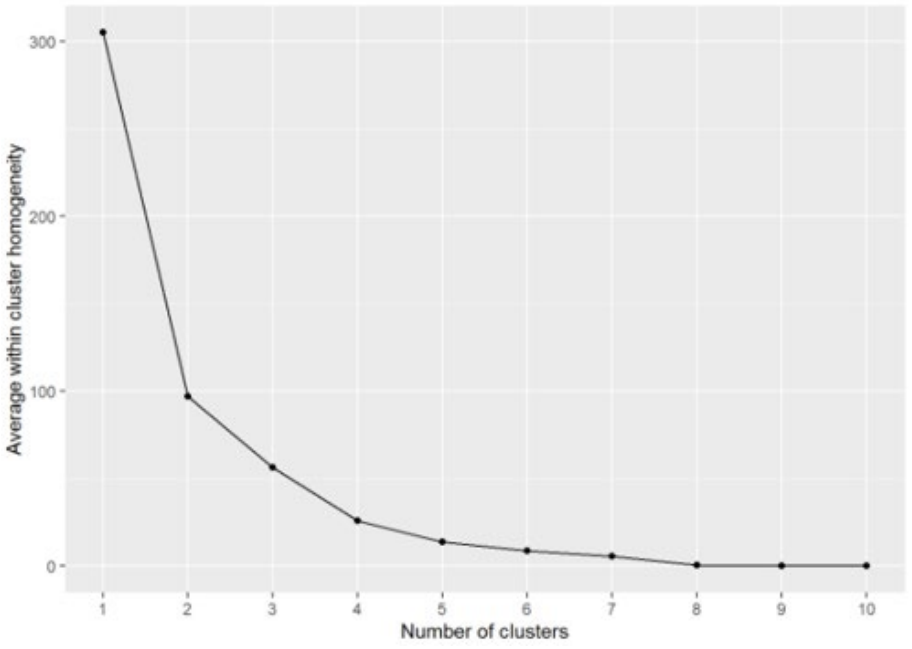


Figure 2b

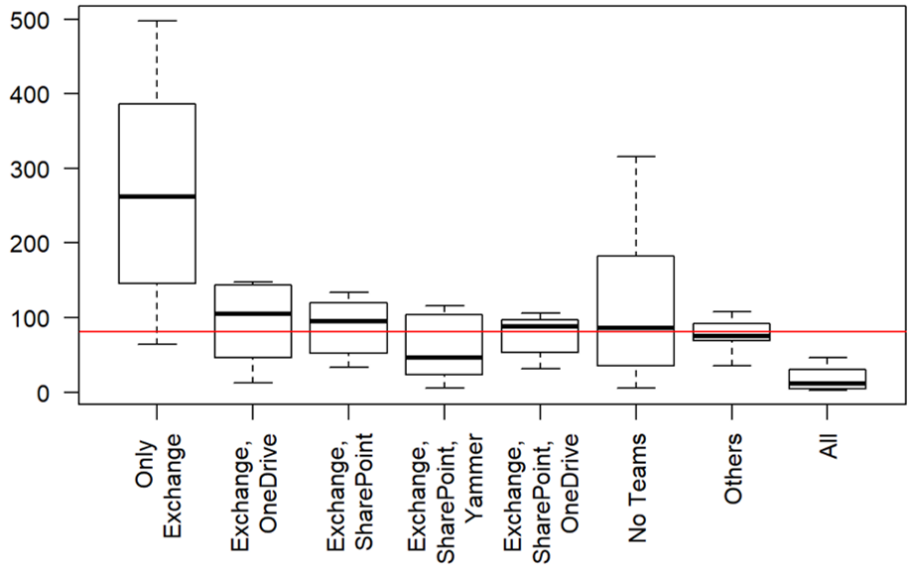


Figure 2c

Figures 2a-c: Representative examples of dendrogram and elbow plot. Box plot of media collection distribution. The red line equals 10% of all employees

TOWARDS A SET OF DESIGN PRINCIPLES FOR COMPUTER-MEDIATED FEEDBACK FOSTERING TEACHERS' PEDAGOGICAL SKILLS: A SYNTHESIS OF THE LITERATURE

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Abstract Developing pedagogical skills of teachers is an essential objective in teacher education. Although feedback from workplace supervisors is considered crucial for encouraging these skills in the first stages of teachers' careers, delivering effective and just-in-time feedback is under pressure due to a teacher shortage in secondary education. Recent technological developments allow alternative sources to deliver feedback provided by innovative technologies. However, a comprehensive picture of effective characteristics of computer-mediated feedback (CMF) is lacking. Therefore, this review identifies studies with the aim of deducing a set of design principles for CMF fostering pedagogical skills. Subsequently, all studies were categorized with respect to learning environment characteristics, learning processes and learning outcomes. The synthesis is a set of principles including personalized, immediate and delayed feedback. Finally, a future research agenda focuses on how these principles could optimize innovative technologies to deliver feedback for teachers in daily practice.

Keywords: pedagogical skills, computer-mediated feedback, design principles, teachers, systematic review.

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1 Introduction

A global shortage of 69 million teachers is putting pressure on the education system (Adubra et al., 2019). Furthermore, the issue is exacerbated as an analysis was published by the Dutch Ministry of Education which concluded that there was an attrition rate of more than 30% of teachers younger than 30 years of age in secondary education within the first five years of their career (Ministry of Education, Culture and Science, 2014). Many countries have similar attrition rates such as: 40% in the US based on a survey, (Ingersoll, 2003), and 30-40% in Australia (Ewing & Manuel, 2005). Of all teachers, 33% dropped out of the profession within five years in the UK (Education Policy Institute, 2021).

To reduce the amount of teachers dropping out, national policies have been aimed at induction. Induction can be defined as "a planned program intended to provide some systematic and sustained assistance specifically to beginning teachers for at least one school year" (Helms-Lorenz et al., 2016). However, this support is under immense pressure as schools struggle to provide induction due to the current teacher shortage.

Novice teachers mainly struggle in the first period of their career with pedagogical skills like classroom management. Pedagogical skills can be defined as "...the ability and willingness among teachers to consistently apply those attitudes, knowledge and skills that promote their students' learning in the best possible way, in accordance with set goals and within the limits provided. This calls for continuous development of teachers' own competence and the design of the teaching" (From, 2017, p.47). Feedback given by coaching and observing (in relation to these pedagogical skills) is the most powerful induction ingredient measured in a longitudinal study on the effects of induction programs (Helms-Lorenz, van der Grift & Maulana, 2016). Feedback is one of the greatest influences on learning and achievement (Hattie & Timperley, 2007). However, as few teachers and coaches are available to provide this induction, there is a need to search for other solutions. There are alternative sources which can provide effective feedback through computers (Schneider et al, 2016; Lavolette et al, 2015). One such example is the use of virtual reality to foster presentation skills (van Ginkel et al, 2019). Therefore this support could be given in the form of computer-mediated feedback (CMF).

There are several reported affordances of CMF in a variety of learning situations such as enhancing: achievement, engagement, gamification, facilitating collaborative learning and real time error correction (Bahari, 2020). Bahari (2020) goes on to state that one of the challenges of providing effective CMF, is that many elements of feedback have not been widely explored. One element of CMF which is studied in language acquisition pertains to whether to use immediate or delayed feedback (Lavolette et al., 2015).

While previous studies have focused mainly on the effect of CMF on students' performances regarding various tasks and skills, proper research on the implementation of CMF to assist teachers is lacking hitherto. In addition, no comprehensive list of design principles for CMF was found in the relevant literature. Thus there is a fragmented picture of design principles of CMF as many of these principles are studied individually rather than being studied as an integrative set. That is why the aim of this systematic review is to distil a comprehensive set of effective CMF components for the development of pedagogical teacher competencies. Such a set of design principles would be of inestimable value to people creating CMF systems of any kind.

This systematic review has been conducted to ascertain what elements of effective CMF are required to develop pedagogical teacher competencies and to synthesize these elements into a comprehensive framework for design principles of CMF. The main question which was to be answered was: How to design CMF in order to foster pedagogical competencies of a teacher?

To conclude, this specific systematic research will provide insight into how to design how to design CMF in order to foster pedagogical competencies of a teacher. The incorporation of these design principles in a computer system utilizing CMF would have several affordances including: increasing the quality of teaching in the classroom, reducing the workload for teachers, creating an alternative for coaching and support of expert teachers, and decrease the dropout rate for novice teachers.

2 Method

The current systematic review attempts to identify the characteristics of effective CMF in order to foster teachers' pedagogical skills. In terms of the characteristics of the learning environment, two classes are identified namely feedback characteristics and system characteristics (van Ginkel et al., 2015). To support the effectiveness of feedback characteristics, system characteristics are identified. System characteristics relate to elements of the learning environment which are not related to the feedback itself, but instead facilitate the usage of such feedback systems. Feedback characteristics include all characteristics both objective and subjective related to the feedback.

The methodological approach regarding the analysis of the articles contained in our yield has been conducted based on the Biggs model (2003) which is a widely accepted framework within the educational sciences. Furthermore, it is a framework within which the categories are broad enough to be able to incorporate the results of this review. Biggs (2003) identifies three separate categories 1) learning environment, 2) learning processes and 3) learning outcomes (see figure 2). Category one contains feedback characteristics or design principles that constitute the independent variable. Category two constitutes the method or argument through which these elements in the learning environment influence category three (performance, which is the dependent variable). After selecting the characteristics of the learning environment and their effects on performance, these aspects were synthesized into design principles following the formula created by van den Akker (1999, p.5). The formula is as follows: "If you want to design intervention X (for the purpose/function Y in context Z), then you are best advised to give that intervention the characteristics A, B, and C (substantive emphasis), and to do that via procedures K, L, and M (procedural emphasis), because of arguments P, Q, and R". Thus design principles in the context of this study are principles which should be adhered to when creating CMF in order to foster teacher's pedagogical skills.

This following section will start with the inclusion criteria that are formulated. Then the search strategy is laid out accordingly, describing the independent and dependent variables. The relevant publications are identified and finally these publications are explored, analyzed and the relevant CMF elements synthesized into a comprehensive framework.

2.1 Formulation of criteria for inclusion

Various inclusion criteria have been formulated. To start with the first requirement, (1) papers were included which were empirical in nature in which automated feedback is related to the competencies of teachers. This is due to the aim of investigating the effectiveness of CMF elements which therefore require empirical studies such as randomized controlled trials. Second, (2) the articles must be in the context of secondary or higher education as the CMF will be focused on teacher pedagogical competencies. In addition, (3) only peer-reviewed articles were included in the results to obtain scientific fidelity. Finally, (4) the time frame is limited from 2010 to 2021 because the rise of innovative technologies such as virtual reality that support feedback started around 2010 (Ministry of Education, Culture and Science, 2019) and we are interested in design principles supporting feedback.

2.2 Development of a search strategy

The keywords for the independent variable were retrieved by starting with keyword searches such as "feedback" and "computer*" after which relevant search results were screened for related keywords and synonyms. The same process is repeated for the dependent variable. A few examples of independent variables that have been included are: "augmented", "instruction", "feedback", "automated". For the dependent variable examples of included keywords were: "performance", "skills", "competenc*". After an exhaustive list of dependent and independent variables had been selected, every combination of the two variables was searched for, with the additional condition being the context of secondary and higher education. This was done by combining all variables in Web of Science with the TOPIC "school" and "educ*". Web of Science (WoS) is the leading scientific citation search platform in the world (Li et al., 2017). At first, a search was conducted with all variables set to TOPIC in Web of Science. However, this led to finding many irrelevant articles. To limit the number of results and to increase the accuracy of the search, the dependent variables were required to be in the title of the articles. In addition, three articles were added through the process of snowballing. This was done to obtain scientific fidelity as these relevant articles in the reference lists of our original yield did not show up based on our search strategy.

2.3 Identification of relevant publications

This systematic search strategy yielded 235 publications. After reviewing the abstract, publications were removed that: showed no relationship between the dependent and independent variable; did not focus on teacher competencies of a teacher or a student who needs to develop a teacher competency; are not published in English; do not include the context of secondary or higher education; or were not empirical in nature. Of the 235 publications which were identified, 199 did not include computer-mediated feedback or were not focused on teacher competencies. A further 19 publications were not conducted in the context of secondary or higher education. The article identification process was performed independently by two researchers to ensure inter-rater reliability. The overlap of choices to include or exclude articles from the yield of 235 publications made by the researchers is (Cohen's Kappa = 1). The Cohen's Kappa has been calculated based on a sample of 15 articles. Therefore, the inter-rater reliability was excellent.

3 Results

The result of this study is based on 17 articles of which three reviews and two meta-analyses which met the exclusion criteria (see figure 1). Out of these articles eight were randomized controlled trials and three were quasi-experimental studies. Further, one was an exploratory study that did have a pre and post-test but no control group. Most studies focused on language acquisition or non-verbal communication with students, for example vocabulary instruction, non-verbal communication, presentation competence, pronunciation, English writing, reflexive journal writing and grammar mechanics. Six studies were done in a non-lab setting classroom or otherwise realistic setting. All others were conducted in a lab or augmented reality/virtual reality setting. The studies were also analysed based on whether they were founded on an underlying theory such as cognitivism or constructivism. A couple of studies did use a fundamental underlying theory of learning, these are: Engeness & Mørch (2016) draw on Vygotskian cultural historical theory, Peeples and colleagues (2018) utilize a cognitive apprenticeship model, while Mirzaei and colleagues (2015) put Lewis's lexical view to the test. All characteristics of the learning environment have been taken into account when formulating the design principles which led to our final model of the seven design principles (see figure 2).

This section describes the seven design principles of CMF that were distilled (see figure 2). Each design principle has its origin in one or more of the publications which we have identified providing the argumentation for its practicability. In the following paragraphs the design principles are layed out in three steps. Firstly, the design principle is formulated including the independent and dependent variable. Secondly, it is stated how many of the articles supported that design principle. Thirdly, an example, taken from one of the 17 articles, of an argument which supports the design principle is given. For each design principle it is indicated what this means in a practical situation.

Coax memory and communicative performance by providing immediate feedback, because the learner can then make a cognitive comparison between the learner solution and the feedback which may have memory benefits. Out of the seventeen articles, five made use of immediate feedback. As suggested by Arroyo and Yilmaz (2018), there is a cognitive window of around 40 seconds that is open in which a comparison can be made by the learner between the current behaviour and the feedback which the learner has received.

Hone student performance by providing elaborative delayed feedback, which in turn induces an effect known as the spacing effect thereby providing an opportunity to re-study the learning material. Five articles made use of delayed feedback (although not necessarily elaborative) and a further four used both immediate feedback and delayed feedback or the timing was not clearly stated. There should be enough time between each feedback message in order to create a new opportunity to study the learning material (Candel et al., 2021).

Alleviate cognitive strain by delivering feedback in manageable units, thus decreasing this strain as a consequence of not receiving too much feedback at once. Consequently, this makes it easier to pay attention to the elements communicated to the learner. Four articles make use of manageable units one of which states explicitly that they make use of this technique. Indeed, Schneider and colleagues (2016, p.321) recognized this element and made sure to utilize manageable units in their randomized controlled trial. They state that "To limit the cognitive load at most one feedback-instruction is given at a time."

Temper cognitive load by delivering feedback using multimodal communication, thereby making it easier to pay attention to the elements communicated to the learner. Multimodal communication is the usage of multiple modes of communication such as: oral, written, haptic and video. This technique of multimodal communication has been made use of in one RCT. This reduced cognitive load makes it easier for the learner to pay attention to the elements communicated to him. Schneider and colleagues (2016) and Peeples and colleagues (2018) provided evidence in their RCT's for the efficacy of multimodal communication.

Buttress the perception of high frequency and high quality feedback by providing personalized feedback, because personalized feedback is seen as being more specific to the students' input. Two randomized controlled trials, two meta-analyses and one review study supported the use of personalized feedback. Furthermore learners feel as if there is more involvement in their progress, thereby increasing their satisfaction with learning. Deeva and colleagues (2021) show that students who receive online personalised feedback consistently have a higher performance and satisfaction with the course compared to students who receive generic feedback.

Optimize cognitive performance by allowing the learner to have a high perceived degree of learner control, because having this perceived control increases the learner's motivation. This design principle is supported by one review study. One of the situations in which a high perceived degree of learner control is beneficial in aiding cognitive performance is in a paired associate learning task, whereby memory is improved (Deeva et al., 2021). In this paired associate learning task, participants were tasked with remembering words in pairs, whereby one group choose the words which were ought to be remembered and the other group did not have a choice.

Trigger an increase in positive emotion by ensuring a low degree of anthropomorphic (human tendency to attribute human traits to non-human entities) human machine interaction because it leads to a sense of comfort. This design principle is supported by the review of Pérez and colleagues (2020). In conclusion, it is important to make clear to the learners that they are not interacting with a human but a computer bot (Pérez et al., 2020).

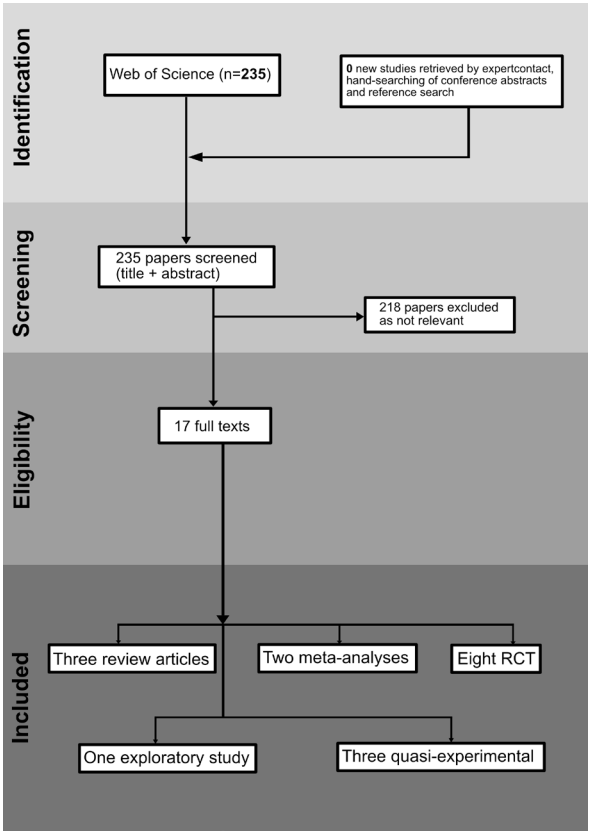


Figure 1: Flowchart of Identification, Screening, Eligibility and Included (yield)

Table 1: Literature yield and study characteristics per design principle

Design principle	Study's	Research design
1	Peeples et al. (2018)	RCT
	Pourhosein Gilakjani (2019)	RCT
	Schneider et al. (2016)	Quasi-experimental
	Lavolette et al. (2015)	Quasi-experimental
	Varank et al. (2014)	quantitative and qualitative
2	Candel et al. (2021)	RCT
	Van Ginkel et al. (2019)	RCT
	Wali & Huijser (2018)	Pretest-Posttest
	Cheng (2017)	RCT
	Engeness & Mørch (2016)	RCT
3	Peeples et al. (2018)	RCT
	Van Ginkel et al. (2020)	RCT
	Pourhosein Gilakjani & Rahimy (2019)	RCT
	Schneider et al. (2016)	Quasi-experimental
4	Schneider et al. (2016)	Quasi-experimental
	Peeples et al. (2018)	RCT
5	Deeva et al. (2021)	Review
	Little et al. (2018)	Meta-analyses
	Little et al. (2018b)	Meta-analyses
	Van Ginkel et al. 2019	RCT
	Schneider et al. (2016)	Quasi-experimental
6	Deeva et al. (2021)	Review
7	Pérez et al. (2020)	Review

Note. 1 (Immediate feedback), 2 (Elaborative delayed feedback), 3 (Manageable units), 4 (Multimodal communication), 5 (Personalized feedback), 6 (High perceived degree of learner control), 7 (A low degree of anthropomorphic human machine interaction)

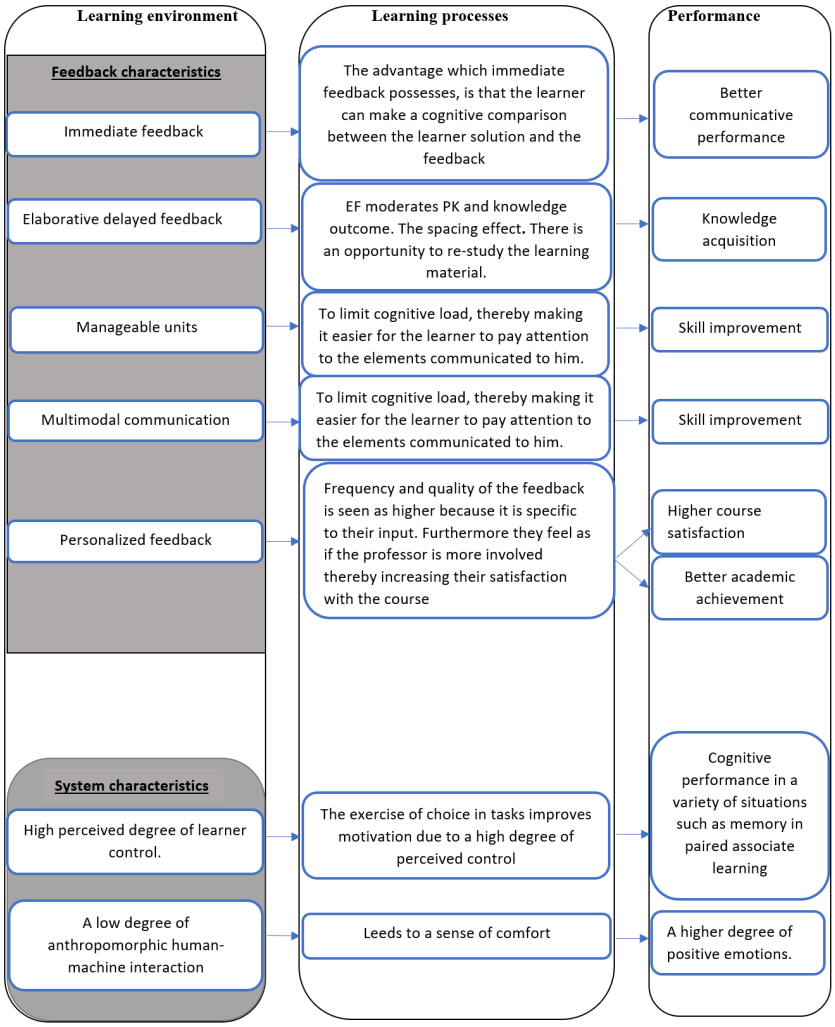


Figure 2: Framework for CMF to foster pedagogical teacher competence

4 Discussion

4.1 Concluding remarks

This study focuses on an alternative method for providing feedback to teachers about their pedagogical skills compared to face-to-face feedback from expert teachers. Reviewing the literature has led to seven design principles for providing

effective CMF. These seven design principles are immediate feedback, elaborative delayed feedback, manageable units, multimodal communication, personalized feedback, high perceived degree of learner control, and a low degree of anthropomorphic human-machine interaction. However, relatively few empirical studies have been conducted looking at the efficacy of CMF. Furthermore, not a single comprehensive overview of design principles for CMF was encountered in this review suggesting that it is a relatively new terrain. All articles which were part of the yield did not utilize all design principles simultaneously. However, it is important to consider all seven design principles when developing a system which delivers CMF in order to extract the most utility from the system. Even though it is important to consider all design principles, based on the application of the system and its specific requirements, CMF system developers can make do without necessarily utilizing all seven design principles.

Several forms of CMF systems could be considered as these design principles will have to be integrated into a computer system. One system type that has increasingly been made use of and has seen much innovation in the past decade within the field of artificial intelligence (AI), is a chatbot. Chatbots are becoming more prevalent in various areas to take over routine information flows such as frequently asked questions. Another type of system which incorporates CMF is an interactive app for developing presentation skills, such as the Honest Mirror AI-driven app (Sakkali et al., 2021). Furthermore, theoretically all seven design principles could be used in concert in such a feedback system. Besides, the use of chatbots or interactive apps are advantageous to create a dynamic interaction between the learner and the system. The design principles which have been gathered in this review, have been found in the context of secondary and higher education and are therefore applicable in the education of teachers. It is not clear to what degree these principles could be used in other levels within education. This provides opportunity for others to test whether these principles could be applied more broadly.

4.2 Limitations

Firstly, a limitation of this study was that the population in many studies were students and not teachers. Therefore, it is not certain to what degree the design principles are specifically applicable to teachers. However, the articles had to focus

on a teacher competency which therefore makes it more likely that the gathered design principles are generalizable to a population of teachers.

Moreover, not all design principles are well supported by the empirical evidence. For example, the article supporting the use of multimodal communication was not trying to answer the question whether multimodal communication was better compared to unimodal communication. This means that this design principle lacks evidence in the shape of being compared with a control condition. The same counts for manageable units which is supported by four articles which make use of this principle, but neither of these four articles' central research question was to provide evidence for manageable units studied in isolation as a design principle.

4.3 Suggestions for further research

Firstly, follow up studies are necessary to determine what makes CMF attractive to use for teachers. For example, it should be determined whether they want to use the system before, during or after giving their lesson. Moreover, which other factors are important for there to be a positive reception of such a system? Maybe teachers would want the CMF system to be available on their smartphones. Therefore, considering the category of system characteristics which influence the willingness to use a CMF system, perceptions from teachers should be taken into account. For instance, it is important to determine at which point in time teachers wish to utilize the system, and whether elaborative delayed feedback is preferable to immediate feedback. Accordingly, a qualitative study using semi-structured interviews should be conducted to gather data on teachers' preferences regarding CMF systems.

Secondly, considering that this review covers new terrain, research should be conducted as to the degree to which these principles contribute to pedagogical competencies of teachers. For example, multimodal communication and manageable units should be researched in the context of teachers utilizing research designs such as a randomized controlled trial. A prototype of a CMF system could be made making use of multimodal communication and manageable units. This prototype can then be contrasted with another prototype system, utilizing an RCT, which incorporates many more design principles in order to distinguish how much the additional design principles add to the efficacy of CMF.

Thirdly, it is important to determine the efficacy of combining every single one of the seven design principles by implementing them into a CMF system, such as a chatbot or an interactive app, and measuring pedagogical skills in teachers. A randomized controlled trial would add to the literature as it would provide evidence for the efficacy of the combined design principles. A field experiment can be conducted to increase the ecological validity, gain insight into the perception of the received feedback, and provide information as to whether the CMF system will be used again.

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An Ontological Exploration of Central Bank Digital Currency Governance Design

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Abstract Financial ecosystems and their related transactions are increasingly relying on big tech payment service providers, such as ApplePay and WeChat. By offering these services, transacting in unregulated cryptocurrencies becomes easier. Consequently, big tech companies take a powerful position in the ecosystem, such dominance may be avoided by a decentralized ecosystem, in which decision making power is distributed over several actors. Emergence of several highly unregulated cryptocurrencies and increased reliance on big tech, motivates central banks to investigate alternatives, called Central Bank Digital Currency (CBDC) that can be subject to governance and rules. CBDC is specifically aimed to decrease dependency on largely uncontrolled big tech payment service providers and to limit the growth of unregulated cryptocurrencies. In this paper, we explore the key question of how to design a governance structure, we do that by applying the DECENT ontology and conceptual models to the real world use-case of CBDC.

Keywords: decentralized governance, ontology, conceptual models.

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1 Introduction

The banking landscape is rapidly changing, due to rise of big tech companies that offer financial payment instruments, which enables and promotes in transacting with unregulated cryptocurrencies as well. Next to these developments, with the introduction of Bitcoin, many parties are now offering cryptocurrencies, and that market has grown significantly. Traditionally, central banks play a centralized role in the governance of the current fiat money ecosystem, e.g. to guarantee economic and financial stability by implementing monetary policy, for exampleto achieve low and stable inflation. Big tech dominance in the financial domain and the growth of unregulated cryptocurrencies requires an answer from the central banks, and that answer is the CBDC, a digital currency that allows for decentralization both in operations and governance. A CBDC will allow central banks to regain control of the disparity currently occurring within the financial domain. The development of CBDC is in full swing, and the outcome, e.g. for the EU, is not very clear yet. In other words, the various CBDCs, as proposed by many countries, are very much ongoing Systems under Design (SuDs).

In (Kochergin & Dostov, 2020), several worldwide initiatives of Central Bank Digital Currency are analyzed, and it is concluded that one of the biggest challenges of implementing CBDC is designing the related governance structures. We define governance as a system in which entities set and decide about the rules, concerned with structure and processes for decision making, accountability, control and behavior of actors (Kaya, Gordijn, Wieringa, & Makkes, 2020). Decentralized governance is done by multiple parties, rather than one powerful actor. As with any design problem, and cf. Design Science (Hevner, March, Park, & Ram, 2004), an important question is which artifacts are needed to express design decisions, and how to represent them.

For CBDC, several artifact types are relevant, but in this paper, we focus on the decentralized governance artifact by taking an ontological approach. As argued, governance is important for any banking ecosystem, and in the case of CBDC, the question is how the governance should look like, and to what extent it should be decentralized. In our earlier work, we have developed and validated DECENT ontology (Kaya & Gordijn, 2021) in the domain of decentralized (peer-to-peer) energy trading. For this paper, we want to understand whether DECENT ontology

holds in another domain as well, which is the governance design of Central Bank Digital Currency (CBDC).

Specifically, we use the DECENT ontology, (Kaya & Gordijn, 2021) as a method to design a governance structure. An ontology represents graphically the relevant governance constructs and the relations between these constructs. Because we have learned, e.g. while validating the e3value ontology (see (Gordijn & Wieringa, 2021)), that visualization of the design artifact reflecting important design decisions is crucial for communication with stakeholders and establishing a common understanding of the SuD at hand, we employ graphical modelling languages. Instead of reinventing the wheel, we use existing modelling techniques, including UML, e3value, i* goal modelling (Yu, 1997), (Gordijn & Wieringa, 2021) to represent a decentralized governance structure, and we show how these relate to DECENT ontology. Goal of DECENT Ontology and the conceptual models is to accurately represent the decentralized governance artefact. This approach allows for (automated) analysis as well. This is precisely our long-term research objective: We want software-support for the design and analysis of governance constructs, and we refer to this field as computational governance. The specific research question is to what extent an ontological approach contributes in understanding and designing a decentralized governance structure for CBDC. The paper is organized as follows. Sec. 2 discusses related work regarding decentralized ontologies.

Then we explain in Sec. 3 our research set up, which is Exploratory Technical Action Research (ETAR). A crucial element in ETAR is the involvement in a real-life case, which is decentralized governance design of Central Bank Digital Currency in Sec. 4, we also introduce and apply DECENT Ontology and the conceptual models in that section. Sec. 5 reflects and discusses DECENT ontology as a method to design decentralized governance. Finally, Sec. 6 presents our conclusion.

2 Related work

An ontological commitment and formalization of governance is an emerging re-search field (Kim, Laskowski, & Nan, 2018). An ontological approach supports the design of governance and ultimately software tool development. Within thedomain of decentralized governance, there is the notion of *Decentralized Autonomous Organization: DAO*, which operates without a central authority. A DAO is an organization that is run through rules encoded as computer pro- grams in the form

of smart contracts (Chohan,2017). A key feature of a DAOis the execution of rules. These rules are executed via smart contracts, which are used as a mechanism to enable participation. A key distinction between DAO and our DECENT ontology is that a DAO is primarily focused on decisionmaking posed as *voting*, which is facilitated via smart contracts. A drawback of a DAO is that participants are motivated by incentives to contribute and itis not a self-governing system. DAO is rather technology focused, and not formalized with e.g. conceptual models, and is an ad-hoc driven process. As DAOsare rather technology focused and there is lack of formalization, the governance design is not easily understood by participants. Furthermore, a DAO does not describe the relationships between parties and their roles which can be *define, execute, monitor*. This is demonstrated by applying the TOVE Organization Ontology for creating a conceptual model to implement a smart contract (Kim, Fox, & Gruninger, 1995). TOVE is rather process orientated and implementation focused, and compared to DECENT Ontology, key elements of governance are not represented. TOVE takes a single actor approach, and not the complete ecosystem, governance requires coordination in the design process over a set of actors. Furthermore, it is not clear how to derive the governance design from the TOVE models. TOVE is missing DECENT concepts such as (self)regulation, legislation and consequently their decomposition into a set of rules, which are essential constructs for decentralized governance. Decentralized governance is about a multi-actor approach and focused on the role every actor plays, DECENT Ontology full-fill multi-actor requirement, for designing decentralized governance.

3 Exploratory Technical Action Research

We want to explore the decentralized governance design structure of a CBDC and, more specifically, how to design the related governance structure. The RQ for this paper is: To what extent contributes an ontological [DECENT Ontology] approach in understanding and designing a decentralized governance structure for Central Bank Digital Currency? Certain studies analyze the idea of 'decentralized governance' ex-post, that is when the governance is already in place and up-and-running. In contrast, we study the contrast ex-ante, as a topic of design, cf. (Erbguth & Morin, 2018) who argues that defining governance is actually a design process. To do so, we have been involved in workshop sessions regarding the development of CBDC with a central bank based in South America and with a leading commercial bank from Europe (see Sec. 4). Using this project, we explored the idea of

'decentralized governance design' in more detail. We call this Exploratory Technical Action Research (ETAR), following the Technical Action Research (TAR) approach, which is often used in the field of Design Sciences (Wieringa, 2014). ETAR comprises the following research activities: (1) problem analysis, (2) design theory, (3) treatment, and (4) treatment analysis. These are all explained in extensive detail in the corresponding sections.

4 Design Theory: DECENT Ontology & Conceptual Models

4.1 Problem Analysis

In our research we consider decentralized governance as a *design* problem, in the philosophy of Design Science, (Hevner et al., 2004) as an artefact to be designed. We do this by researching a case concerning Central Bank Digital Currency (CBDC). A CBDC is a digital currency, denominated in the national unit of account, which is a direct liability of the central bank, such as physical cash and central bank settlement accounts (Amaral, Sales, & Guizzardi, 2021).Only a central bank can issue CBDC and is the sole custodian. By introducing CBDC, a central bank can streamline payment transactions to protect privacy of citizens and ensure that citizens and companies have equal access to trustworthy digital payment solutions. However, how to design and introduce CBDC, since it involves a complex redesign of the financial ecosystem with many participating actors, is identified as a governance challenge. Currently, many central banks worldwide are experimenting with CBDC and it has been identified that one of the biggest challenges for CBDC is how to design the related governance structure. In Design Science, the notion of "artefacts" is key. In our research, we want to express artefacts in terms of *conceptual* models (see e.g. (Brodie, Mylopoulos, & Schmidt, 2012)) to be designed. A semi-formal specification (Ontology) and conceptual models facilitate for a better and shared understanding of the domain at hand, and supports automated proof of correctness of models and computer-assisted analysis of the domain at hand (e.g. compliance with governance rules set by law). For now, our goal is much more modest, as we wantto understand whether an ontological approach and model-based artefacts canassist in designing governance (Kochergin & Dostov, 2020).

4.2 Introducing: DECENT Ontology

DECENT *Decentralized* ontology is a lightweight tractable *reference* ontology with a clearly defined set of governance concepts. Intended user-base are consultants that will actually have to design governance structures. The ontology, depicted in Fig. 1, is expressed using a semi-formal specification and represented as an UML class diagram and specifically developed to use as an instrument to develop the domain, by identifying the design requirements in order to develop the governance structure. We argue that in order to develop decentralizedgovernance, we have to understand the to-be developed domain and the relatedrelations. DECENT Ontology provides a clear and structured approach in defining governance constructs and the relations. DECENT Ontology is unique as it takes a multi-actor approach, which is crucial when developing decentralized governance, as there is no single actor anymore orchestrating the ecosystem at hand. Each actor has a specific role —*define, execute, monitor* — which influences how governance design decisions can be taken. We demonstrate how DECENTontology can be used as tool to develop and increase the domain understandingby describing the governance structure of CBDC in Sec 4.3 Treatment: DECENT Ontology CBDC. Furthermore, we claim by developing the governance constructs as a starting point, this will contribute to develop and derive the governance design structure for the conceptual models. We have developed the domain of CBDC in multiple workshop sessions with a central bank from South America and a leading commercialbank from Europe. These sessions provided input for describing the domain of CBDC. For detailed explanation of DECENT ontology, please see (Kaya & Gordijn, 2021). CBDC is still an exploratory design and research field, both central bank and commercial bank identified this as a System under Design and with many design decisions to be taken along the way, which fits in the exploratory element of this paper.

4.3 Treatment: DECENT Ontology CBDC

A *Party* represents any participant in the CBDC ecosystem, for example citizens, commercial banks, big tech companies and central banks. A *Party* can be an *Actor* or a *Group*. *Actors* are entities responsible for their survival and well-being. *Actors* can take their own legal and economic decisions and are perceived by themselves and their environment as independent entities (Gordijn & Wieringa, 2021). For example, a *citizen* owning a digital wallet is an independent entity capable of making their own

economic and legal decisions. A *Group* is a collection of *Parties* that share one or more characteristics, for example decision taking method. A *Group* is, for example, several commercial banks group, who all have to comply with the same governance rules.

A *Party* can play several *Roles* with respect to governance in a particular ecosystem (e.g. a central bank plays a defining role in relation to commercial banks). In DECENT, *Roles* focus on the position of the *Party* in relation to a *Governance Construct*. The position is a selection of set, e.g., determine a rule, execute, e.g. be compliant to a rule, and monitor, e.g., collect information to check compliance to a rule. As example, the EU sets the General Data Protection Regulation (GDPR) in Europe, and the European Central Bank sets that CBDCs must safeguard consumers' privacy. The *commercial banks* ensure users' privacy when operating (executing) CBDCs, and the *Central Bank monitors* compliance of the *commercial banks* with GDPR.

The Governance Construct serves as an essential part of the ontology as it collectively represents the subject that an *Actor* or *Grou*p plays a *Role* in. The Governance Construct is the generalization of *Decision Making, Rule, Rule Set, Mechanism, Policy, Goal, Objective, and Incentive*. To prevent unnecessary cluttering of the diagram, these generalization relations are not graphically represented. Modelling this way implies that an *Actor* or *Group* can play a *Role* in all these constructs. For example, a *central bank*, via *Role* of regulator, can define a *Rule* (a Governance Construct) requiring the implementation of digital wallets.

A Governance Construct may be affected by one or more *Roles*. A *Role* uses *Decision Making* to reach agreement. *Decision Making* refers to a collection of methods used by a *party* to take a *decision* regarding a *Governance Construct*. The choice for a particular *Decision Making* depends on the *Rol*e a particular *Party* has in relation to the *Governance Construct* at hand.

A *Rule* expresses something required, permitted or prohibited (e.g. CBDC must consider anti-money laundering and counter financing of terrorism risks). A *Rule Set* is a coherent set of rules (e.g., EU Anti-money Laundering Directive EU 2015/849). *Legislation* and *Regulation* are specific types of *Rule Sets*. While *Legislation* is set by a government, *Regulation* can be set by a society of *actors,* a branch organization, or even can be self-imposed by one or more a*ctors* ('self- regulation'). Therefore, it has

not a formal legal character in the sense of laws. A *Rule-Set* is implemented by a *Policy*, which can be defined as a plan for action, consisting of a coherent set of mechanisms to implement a *Rule* that follows from a *Legislation* and *Regulation.*

A *Rule-Set* can contribute to satisfying a *Goal,* which is a desire to fulfill, for which an *Actor* has committed resources. Usually, a number of related *Rule* are needed to reach a *Goal.* Examples of central banks' *Goals* regarding CBDCs are fostering financial inclusion and ensuring financial stability.
Objectives measure satisfaction of a *Goal.* While *Goals* are stated qualitatively (e.g., implementation of digital wallets), *Objectives* allow to *measuring* achievements of the *Goal* (e.g., implement digital wallets free of charge for all citizens by 2024). In some cases, multiple *Objectives* need to be achieved for *Goal* satisfaction.

Finally, an *Incentive* is stimulation to achieve *Objectives* and indirectly obey to *Rules. Actors* can be motivated to strive for reaching an *Objective* and hence *Goal* satisfaction. A *Reward* is a motivation to achieve *Objectives* and indirectly adhere to *Rules* (e.g., an attractive interest rate to stimulate citizens to adopt CBDC instead of physical cash). A *Penalty* is a punishment if *Objectives* are not met and *Rules* are not adhered to (e.g., if a customer's privacy is violated, a Penalty can follow for the commercial bank, gives by the central bank).

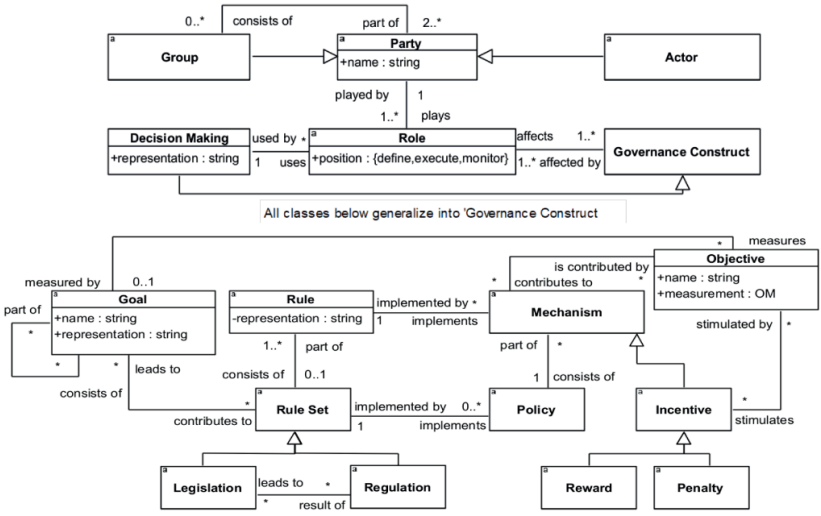


Figure 1: DECENT Ontology

Treatment analysis: DECENT Ontology How does an ontological approach contribute towards governance design? When designing a governance structure that requires input from multiple groups and actors, a graphical overview con- tributes to a common understanding of the developed area. With DECENT Ontology the conceptual domain of CBDC from a governance perspective have been described and also how the roles affect each other. Otherwise when developing governance, without DECENT Ontology, you risk that it becomes too broad and not structured. Having a graphical representation of the required governance constructs and the relations between them proved to be valuable to describe as it was clear to see that the relations between the governance constructs are equally as important. When developing a decentralized governance structure, a multiple actor approach is required instead of one actor. It is crucial that actors have the same viewpoint and agree on the state and the governance constructs that needs to be developed, beforehand. These design issues are usually very costly to develop, and require big investments from all parties. Therefore, it is important to agree on the initial state beforehand.

4.4 Treatment: Conceptual Models

When designing Decentralized Governance for an ecosystem with decentralized decision making, the role of actors is crucial, as close collaboration is required between actors. A method to distinguish the roles, goals and responsibilitiesis by creating conceptual models. For this paper we consciously selected the *e³value* business model and *i** Goal Model as these focuses and differentiate different roles per actor. Designing all governance artefacts, based on the domain description of CBDC that DECENT Ontology provided in previous section is a significant amount of work that exceeds the reporting space in this paper. Therefore, we focus in this paper on the e3value business model and goal artefact. Also, we consider the artefacts as representations of governance design.

Treatment: e³value Business Model CBDC In our modest view, a CBDC ecosystem should start with the business model first, as it defines how the CBDC ecosystem will generate value streams for all actors involved, how and to whom 'sales' is occurring, and what type of service/products will need to be developed. To express the business model, we require a language, from a governance perspective, and for that purpose, we apply the *e³value* methodology (Gordijn & Akkermans,

2018). This a tractable method for business development specifically designed for multi-actor approach and ecosystem design. In figure 2 we present a simplified business model for the CBDC, expressed as an *e³value* model. Based on conversations with commercial and central bank we understood that a hybrid approach will be taken, in which fiat money and CBDC will co-exist. The *e³value* Business Model presented in Fig. 2 is based on DECENT ontology, *italic* words refers to governance concepts of DECENT. Note that this model (and the otherstoo) show only partly the notion of CBDC, which is a domain too complex tobe captured in a single publication. We specifically used the DECENT Ontologyas we are interested in translating business model to a structured governance design. *Parties*: Customers *actor*, Commercial Banks *Group,* and Central Bank *Group*. By identifying the *party* we were able to identify the goal per party, namely: Access to fiat and digital money *goal*: Citizen: Provide fiat and digital money *goal*: Commercial Bank, Central Bank: Issuing digital currency *goal:*

Central Bank. By identifying the *party* and related *goal*, *party*, value exchanges between *a-party* is modelled. This is based on the role that a party fulfills to satisfy their own needs *goal*. A Customer has the *goal* to be able to transact with fiat and digital currency. Once a Customer *actor*, is able to transact with digital currency, it can engage in further economic activity such as obtaining a loan from a Commercial Bank. The *group Commercial Bank*, engages with a *Customer actor* that requests service, and executes the request of fiat money for the *Customer actor*. However, a *Commercial Bank group* can only transact with a Customer if their banking license is *defined and monitored* by a *Central Bank*. Furthermore, *a Central Bank group, defines, executed and monitors* the total money supply, and is the sole custodian of CBDC.

Treatment analysis: *e*³value CBDC Business Model We first present a table, that provides a high-level conceptual overview on the relations between DECENT Ontology and the *e³value* (Table 1). This provides a starting point in extracting the governance design based on the business model for CBDC. Italic words refer towards DECENT Ontology, this to provide a structure for a coherent design approach. When designing a new ecosystem, it is important to understand the value transfer between *actors*. Through this structured model and approach, the relevant *actors* and *groups* are identified. Furthermore, *goals* and *roles*, determine how a *party* interacts within the CBDC ecosystem. Business model identification per participating *party* is important otherwise the required governance decisions will not

be followed. This model can ensure that all involved have the same notion of which *party* and *actor* will be engaging with CBDC. The model demonstrates that coordination between *actors* is absolutely necessary. Within a CBDC setting the responsibility of distribution of CBDC will change significantly compared to the current governance structure of distributing fiat money. As the infrastructure for CBDC transactions will have to be equalized and interoperable with the financial ecosystem, the question then arises who needs to govern and develop the corresponding infrastructure. This also shifts the governing *role* of the Central Bank, as we need to develop new *mechanism* to implement the *regulatory* oversight from the Central Bank and how exactlymoney will be issued.

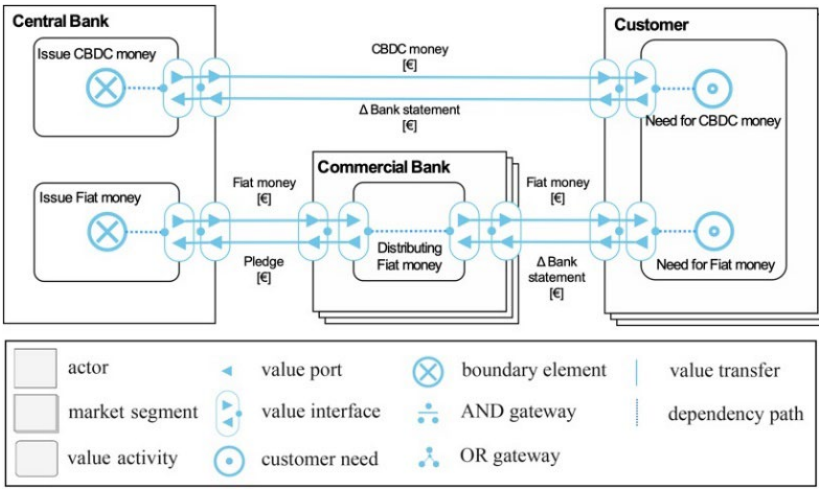


Figure 2: e3value CBDC Business Model

Table 1: Representation of DECENT concepts in e³value

Governance Concept	Representation in e³value
Party, Actor, Group	Actor or Market Segment
Goal	Value Activity or Customer Need

Treatment: CBDC *i Goal Model** The goal model is developed based on the DECENT ontology constructs *goal* and *party*. Through goal modeling it is possible to identify actors and the relations between them, the goals they intend to achieve, goal dependencies, and to represent the conflicting goals as well. Fig. 3 depicts a goal

model for the CBDC Ecosystem, using the i* framework (Dalpiaz, Franch, & Horkoff, 2016). As we want to present a comprehensive CBDC model, we modelled a high-level goal overview. All words in *italics* refer to *governance concepts* of DECENT. In the model, the CBDC ecosystem is represented as an agent and refers to the ecosystem itself. The four parties, namely, Customer, Company, Commercial Bank and Central Bank, are represented as *actors*. Moreover, the model depicts the dependency of each of these parties within the CBDC Ecosystem. The Citizen's goals are "Transact digital currency", "Privacy preservation" and "Have access to financial services offerings". Note that there is a conflict between the two last goals, as to propose better financial services offerings, Commercial Banks in the ecosystem need to have access to more (private) information about the Citizen. The Central Bank's goals represented in the model are "Ensure financial stability" and "Foster the financial system efficiency", "Financial inclusion" and "Safeguard consumers' privacy". Here we have also conflicting goals as there is a trade-off between fostering efficiency and ensuring stability. Commercial Banks have as goals "Provide financial services" and "Comply with GDPR and Central Bank's regulation", this latter related to preserving consumers' privacy. Finally, Company has as *goals*, "Economic growth" and "Comply with GDPR" as it is required by law to preserve customers' privacy. The mapping between the ontological DECENT concepts and the representation in the *i** Goal Model is listed in Table 2.

Table 2: Representation of DECENT concepts in *i Goal Model**

Governance Concept	Representation in *i** Goal Model
Party, Actor, Group	Actor or Agent
Goal	Goal Dependency or Quality Dependency or Conflicting Goal

Treatment Analysis: CBDC i* Goal Model We have learned that, when designing decentralized governance, it is important to have a clear overview of the participating actors and their respective goals. Being able to identify the goals per party provides a broad view of how CBDC can be successfully implemented, from a governance perspective. By eliciting goals, we can also identify the conflicting goals, and consequently we can be more proactive in our governance approach. Goal modelling is also strategic, as it is important for any project to identify the risks (=conflicting goals) as early as possible, in order to mitigate them. Decentralized

governance design is also about clear and concise communication about rules of engagement and goals. A goal model can contribute to achieving this as with decentralized governance is that actors collaborate in deciding the rules of engagement and how decisions are made. However, each actor acts from their own goals to be realized, one of the goals of governance design is that it creates transparency between participating actors, which a goal model facilitates.

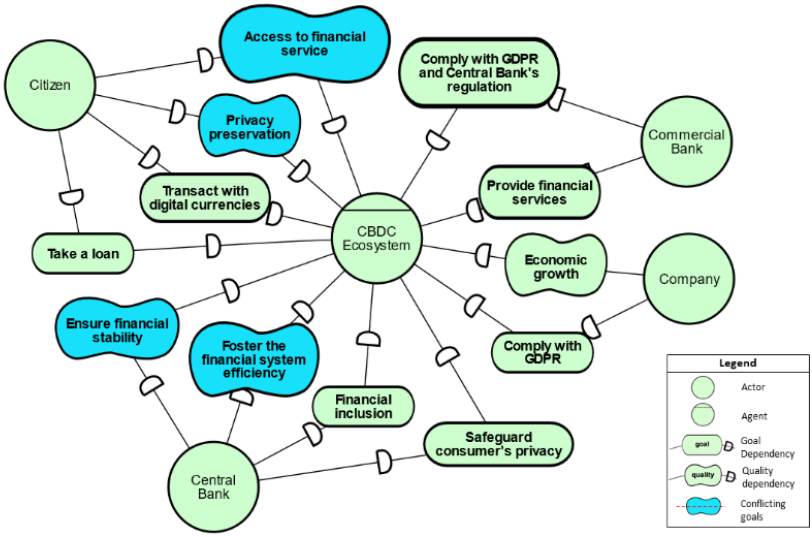


Figure 3: i* CBDC Goal Model

4.5 Treatment Evaluation: DECENT & Conceptual Models

By taking an ontological approach, we were able to instantiate and represent the governance design and the relations in the domain of CBDC. Without claiming to be exhaustive, nor claiming that the decisions are final, as both our contacts at the Central Bank and Commercial Bank stated clearly that CBDC is in full swing development. We see that the role of several important actors is changing by introducing the CBDC next to fiat money. We present below a list of governance design decisions, which is related to the treatment sections of DECENT Ontology, *e³value* business- and *i** Goal model. Words in *italic* refer to DECENT Ontology CBDC domain.

- CBDC issuance will be executed by *Central Bank*
- Distribution of Fiat money will co-exist with CBDC and Fiat money will still be *executed* by *Commercial Bank*
- *Central Bank* will continue *monitoring* and e*xecuting* audits at *Commercial Banks*
- *Central Bank* can punish via *penalty* if privacy of actors is violated with the digital currency CBDC, for instance by revoking banking license
- CBDC design by *Central Bank* will follow the open-banking PSD2 standardization to enable *actors* to have full ownership of their data and related transactions
- CBDC transactions and privacy [GDPR] will be *monitored* by *Central Bank*
- Distribution of CBDC can possible be *executed* only via the *Central Bank*
- Business model and thus the *roles* of *Commercial Bank* and *Central Bank* will change since distribution of CBDC will possibly be done only by *Central Bank*
- Withdrawal of CBDC can be processed directly possible without the *role* of a *Commercial bank*
- It is clear that current existing *roles* with fiat money compared to CBDC will change significantly mainly between the *Central Ban*k and *Commercial Bank*

5 Discussion

Validity. The question raised at the start of the paper is to what extent an ontological approach contributes in understanding and designing a decentralized governance structure for CBDC. The central claim of DECENT is that it can be used as a *reference* ontology to design and develop decentralized governance. It is intended to help define the right questions to be asked during the design of a governance system. In this paper we used DECENT as a method to develop the CBDC domain and consequently to design conceptual models. It is important to note that CBDC ecosystems, as proposed by many countries, are ongoing Systems under Design (SuD), and, consequently, their design is not finished yet. The models presented here describe a minimalistic view and first step in understanding the requirements of governance design for the CBDC domain. Furthermore, decentralized governance design is a coordination process that requires different points of view, the conceptual models used (*e*^{3}*value* and *i** Goal Model) capture these different perspectives, and are structured by using DECENT Ontology.

Limitations. This paper has limitations, when designing governance structure, actors play an important part because it influences governance design. Our approach is clearly not exhaustive for all actors that operate within the complex CBDC ecosystem. We have taken a first exploratory approach if we can design and model decentralized governance for certain actors. Each actor and their corresponding role need to be elaborated further in order to have the full spectrum of governance design.

6 Conclusion

DECENT is an ontological well-founded conceptualization that can be used for decentralized governance design and this exploratory study gives a first impression of how DECENT Ontology and the resulting, e3value model and *i** goal model can contribute in achieving this. We have demonstrated the use- fullness of DECENT Ontology by developing the domain of CBDC, furthermore, we were able to derive governance design decisions by integrating the concepts of DECENT with the conceptual models. For future work we plan to test and validate the DECENT Ontology, in the domain of Fractional Reserve Banking and Intellectual Property.

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BARRIERS TO DATA-DRIVEN DECISION-MAKING AMONG ONLINE RETAILERS

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Abstract This study investigates the barriers to data-driven decision-making among online retailers. The study seeks to deepen the previous knowledge by considering data-driven decision-making as a process and identifying the critical obstacles within its different (6) stages. Qualitative interview data (N=10) collected from Finnish e-commerce professionals are analyzed. The findings show that barriers to data-driven decision-making occur at all stages during the decision-making process. The barriers are mostly related to the employees' and the management's expertise in collecting, organizing, analyzing, summarizing, synthesizing, and prioritizing data. In addition, attitudinal, technical, and strategy-related barriers can hinder data-driven decision-making. The findings suggest that all the stages included in the data-driven decision-making process and the obstacles that prevent data-driven decision-making during the different stages should be carefully investigated and considered by online retailers.

Keywords: data analytics, data-driven decision-making, online retailers, e-commerce.

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1 Introduction

Decision-making is one of the most significant factors influencing an organization's performance as decisions guide the organization's all activities. The organization's failure or success depends primarily on its ability to utilize information and make decisions in a competitive business environment (Porter & Millar, 1985). The prevalence of information technology and the internet has enabled companies to collect large amounts of data and use it in their decision-making. More and more companies base their decisions on data-based analytics instead of management's "gut instinct" (Brynjolfsson, Hitt, & Kim, 2011). It has been noted that data-driven decision-making has many beneficial effects on an organization's performance and competitive advantage (Sumbal, Tsui, & See-to, 2017; Rialti et al., 2019). Data collection and analysis are considered necessary to facilitate the management's actions and decisions (Pohl, Staegemann, & Turowski, 2022).

Efficient use of data analytics is a crucial management tool for online retailers in particular (Phippen, Sheppard, & Furnell, 2004). Data analytics is the key to tracking customer behavior and gathering important information about the customer. Data analytics (also called marketing analytics) provides methods for measuring, analyzing, predicting, and managing a company's performance to maximize effectiveness and return on investment (Wedel & Kannan, 2016). Because of its importance, data has been called "the oil" of the digital economy (Wedel & Kannan, 2016). Furthermore, the online environment is constantly changing because of technological advancement. It forces online retailers to maintain their competitiveness and continually seek new ways to improve their business models and find new business opportunities based on data.

However, even though data-driven decision-making is highlighted nowadays, effective usage of analytics can be a big challenge for small companies in particular. It has been suggested that it may be hard to understand how to collect and utilize information strategically (Alford & Page, 2015). Previous research has shown that the most significant barriers to analytics usage include lack of resources, budgets, and skills (Chaffey & Patron, 2012), low-quality data, and inappropriate data analytics tools (Ghasemaghaei, Ebrahimi, & Hassanein, 2018). The involvement of top managers and a supportive organizational culture are also recognized as central issues in the deployment of data analytics (Germann, Lilien, & Rangaswamy, 2013;

Maxwell, Rotz, & Garcia, 2016). In addition, although the debate over data analytics has been lively, few studies have focused on examining the challenges of data-driven decision-making among online retailers and during their decision-making processes. Hence, this study seeks to deepen the previous knowledge by concentrating on online retailers' perspectives and considering data-driven decision-making as a process. The study aims to identify and describe the main barriers to data-driven decision-making at different stages of the decision-making process.

This study continues with the theoretical background in which the data-driven decision-making process is discussed. The theoretical section is followed by the methodology and the study's findings. The last section discusses the findings and gives some suggestions for future research.

2 Theoretical background: Data-driven decision-making process

Organizations' use of information in decision-making has been investigated in numerous studies (e.g., Choo, 1996; Nonaka & Konno, 1998; Rowley, 2007). Choo (1996) notes that organizations use information strategically in three areas. These include: making sense of changes in the operation environment, creating new knowledge for innovation, and making decisions about courses of action. In addition, data-driven decision-making has been discussed extensively (e.g., Brynjolfsson, Hitt, & Kim, 2011; Provost & Fawcett, 2013; Brynjolfsson & McElheran, 2016). Data-driven decision-making (DDDM) refers to activities where decisions are made based on the analysis of data rather than only based on intuition (Provost & Fawcett, 2013). Data is collected and analyzed so that the company can make better, more informed, and faster decisions. In the context of online retailing, data can include, for instance, clickstream, transaction, voice, and video data (Davenport, 2012). However, it has been noted that many companies that invest in data analytics cannot take full advantage of using data analytics tools (Ghasemaghaei, Ebrahimi, & Hassanein, 2018).

The data-driven decision-making process is typically pictured by dividing it into phases: collect, analyze and use (Maxwell, Rotz, & Garcia, 2016). One of the best-known models for data utilization in decision making is the DIKW pyramid, also known as the Information hierarchy, Wisdom hierarchy, and Knowledge pyramid

(Rowley, 2007). Even though the origin of the hierarchy is uncertain, it has been utilized in information science discussions for many years (Wallace, 2007).

The DIKW model explains how organizations can move from data (D) to information (I), knowledge (K), and wisdom (W) with their actions and decisions. Even though there are multiple interpretations of the model, the core idea is that each phase during the continuum is a step towards a higher level of understanding. Zeleny (2006) notes that the process includes the steps of know-nothing (data), know-what (information), know-how (knowledge), and know-why (wisdom).

This study mainly relies on Mandinach, Honey, and Light's (2006) interpretation of the DIKW model (Figure 1). Mandinach et al.'s version is supplemented with the help of related literature (e.g., Ackoff, 1989; Rowley, 2007). Mandinach et al. (2006) include only three main phases in the decision-making process: data, information, and knowledge. They also list six actions (collect, organize, analyze, summarize, synthesize and prioritize) that are crucial during the decision-making process.

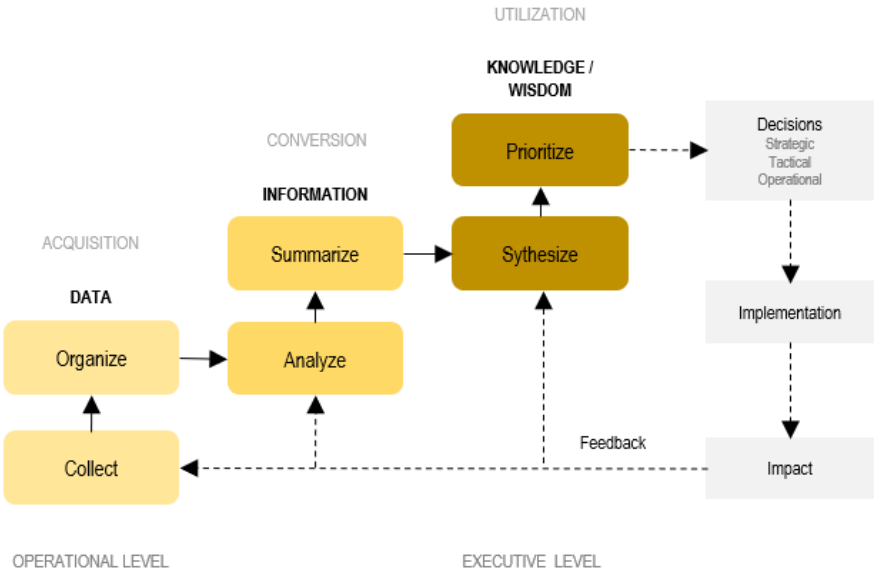


Figure 1: Data-driven decision-making process. Adopted from Mandinach, Honey & Light (2006), Ackoff (1989), and Rowley (2006)

According to Mandinach et al.(2006), data refers to the collection of facts in a raw or unorganized form. Data includes symbols that describe the properties of events, objects, and their environment (Baskarada & Koronios, 2013). Data can exist in any form, including numbers and characters. It does not have meaning in and of itself; hence, whether it becomes information depends on the people looking at the data. Important issues regarding data include how data is *collected* and *organized*. The organization must decide what data is collected and which data collection should be helpful. After the data is collected, it must be organized systematically to be made sense of.

Information comes into existence when raw data is *analyzed* and *summarized*. Data turns into information when it is further processed – when it is connected to a context and given meaning (Mandinach et al., 2006). It answers the questions of who, when, what, where, and how many (Ackoff, 1989). It is vital to produce targeted and concise summaries of information that can be transformed into usable knowledge (Mandinach et al., 2006).

Knowledge is achieved when the organization *synthesizes* the available information and *prioritizes* the knowledge (Mandinach et al., 2006), meaning that it is used to achieve goals and guide action. Knowledge answers the how-to questions (Ackoff, 1989).

The concept of wisdom has received limited attention in the literature (Rowley, 2007) because it is difficult to distinguish between knowledge and wisdom. Zeleny (2006, p. 7) states that wisdom includes understanding why things should be done; it is a "socially accepted or experience-validated explication of purpose. " As noted before, Mandinach et al. (2006) do not mention the wisdom-layer in their model, but similar ideas are included in *knowledge*.

To sum up, organizations first need to acquire data, convert it into usable information and, finally, utilize the engendered knowledge and wisdom in decision-making to be data-driven. Following these ideas and the decision-making framework presented in Figure 1, the empirical investigation of this study aims to find out:

- what prevents online stores from collecting and organizing data
- what prevents data from being analyzed and summarized

- what prevents the synthesis and prioritizing of the obtained information.

The methodology used to find answers to these questions is described in the next section.

3 Methodology

As this study aimed to identify and describe the barriers to data-driven decision-making among online retailers, a qualitative approach was selected. The data was collected by interviewing ten Finnish e-commerce professionals with more than four years of experience in spring 2021. The interviewees included, for instance, CEOs, managers, and web analysts. The interviews of those working in different positions were aimed at gaining a broad view of the topic of the study. A detailed description of the participants is provided in Appendix 1.

The interview guide was semi-structured as the aim of data collection was to explore the participants' thoughts and beliefs about the research topic. Similar themes were discussed with each participant. The exact questions, however, varied within the discussions. The discussed themes included the professional background of the interviewees and their perceptions of data-driven decision-making and data analytics in Finnish online stores. The discussed topics included, for instance, the importance of data analytics in the context of e-commerce and the benefits and problems associated with data-driven decision-making. The average length of the interviews was 38 minutes.

The interviews were recorded and transcribed. After that, the written data was analyzed with the qualitative data analysis software NVivo. All the barriers mentioned by the interviewees were first picked from the data and named according to their content. As a result of several rounds of coding and interpretation, the barriers were eventually grouped into four descriptive themes under the six main phases of the data-driven decision-making process framework presented in Figure 1. These findings are discussed next and are summarized in Appendix 2.

4 Findings: Barriers to data-driven decision-making among online retailers

The findings indicate that various issues can be barriers to data-driven decision-making among online retailers. Barriers exist at every phase of the decision-making process. The findings show that barriers are mostly linked to staff and managers' (1) *expertise*. In addition, (2) *attitudinal*, (3) *technical*, and (4) *strategic* barriers were identified. The barriers occurring at the different stages of the data-driven decision-making process are discussed next.

4.1 Data collection

The analysis shows that barriers in data collection are related to attitudes, expertise, and technical issues. The identified attitudinal barriers included prejudices and unwillingness to invest in analytics. The participants concluded that even though data analytics' benefits are highlighted in today's discussions, all online retailers may not have a positive attitude towards analytics.

> "The difference in attitudes is staggering. Attitudes may be like night and day. [...] Some companies may have an internal culture where data is seen as a threat that destroys jobs." -P5

The expertise barriers were linked to a lack of knowledge and understanding of data analytics. Online retailers do not always understand the possibilities of data analytics or do not have the necessary knowledge on how to collect data.

> "You often hear e-commerce retailers being told that data is the king, but nobody really tells you how to use it." -P3

The technical barriers were related to platforms and combining different sources of data. The participants stated that the platforms used by online retailers do not always support data collection in the best possible way. Combining partners' systems and different platforms in data collection is challenging as the various data sources may not communicate with each other.

> "Analytics is not so simple because there are so many platforms, Google, Facebook, marketing platforms, e-commerce platforms, and they don't communicate with each other in a snap of a finger." -P9

4.2 Organizing

Only expertise barriers, including lack of systematicity, problems in managing collected data, and information overload, were identified concerning the organizing phase. The participants noted that data structuring and organization are often unsystematic. This is typically related to the amount of data and information overload: there is so much data that it is unknown what should be done about it or how it could be organized sensibly.

> "The biggest problem is that there is too much data." -P10
> "Even though there is a lot of data, there is no knowledge of how to segment it to make sense of it." -P6

4.3 Analyzing

Analysis-related barriers included expertise and technical barriers. The identified expertise barriers included lack of routines, amount of analysis, skills, and knowledge. Technical barriers were affiliated with data quality: the collected data can be of poor quality, and thus it is challenging or even impossible to proceed with it.

It was concluded that data analysis often lacks routines. In the worst case, the analysis is not done at all. In other cases, the analysis is done randomly, for example, when there is some time available. The participants addressed that even though most online retailers collect data at some level, they often lack knowledge about analysis, and wrong issues are paid attention to.

> " The biggest challenge is that wrong things are measured." -P6

This was partly explained by the fact that there is a shortage of employees with data-analysis skills. If the analysis is perceived as necessary, it may not be possible to hire staff for it.

> "The biggest problem is that there are not enough people or not enough skilled people. [...] That is why I'm working with a lot of customers at the same time: they can't get people recruited." -P5

4.4 Summarizing

Expertise barriers characterized the summarizing phase. It was noted that summarizing the analysis results can be difficult if the analysis does not provide information on relevant issues or the findings are not outlined understandably.

> "Many times, you see that customers have metrics, but they don't match the objectives. For instance, you don't measure the right things for the objectives." -P6

The identified barriers also included overanalyzing and misinterpretation. If the analysis is made too complicated, it also makes obtaining sensible summaries and results challenging. The analysis might also be performed incorrectly, which distorts the received results.

4.5 Synthesizing

Expertise barriers were also highlighted in the synthesizing phase. It was noted that online retailers might ignore the overall picture when considering the different analyses and summaries. Some aspects of business are looked at very closely, but at the same time, other important issues are overlooked. In addition, the participants concluded that online retailers do not have enough knowledge of how to combine different analyzes. Also, analyses and results can be interpreted differently at the different levels of management and employees.

Outsourcing the analysis process to consults was raised as a problem related to synthesizing. Consultants do not typically have access to all the necessary information, and because of that, they do not understand the company's overall operations. Hence, the information provided by consultants may be fragmented and does not take into account all the matters relevant to the business.

> "Buying from outside is not a solution. [...] You should be able to make different assumptions based on the data, test them, and do continuous iterative testing. It requires that you are inside the business. " -P10

In addition to expertise, some attitudinal barriers were identified. It was noted that the differences in staff expertise in data analytics could be huge. As employees do not have a common understanding of the topic, communication problems occur when synthesizing the information. Furthermore, it was suggested that the most skilled employees might show negative attitudes toward the employees with less data-analytics skills. One of the interviewees called these employees "data snobs," as the following quote demonstrates.

> "It can easily create a situation where someone is a bit of a data snob. [...] You don't want to talk about it when you are at such a different level, even though you should be talking about it." -P2

4.6 Prioritizing

Prioritizing barriers included attitudinal, expertise, and strategy-related barriers. The attitudinal barriers were characterized by willingness and courage. It was highlighted that routines and old ways of doing things often limit the utilization of data analytics in decision-making. Making data-analysis-based decisions can be perceived as challenging. It was reported that online retailers might not have the willingness or courage to change old habits and make decisions based on data analysis. Instead, managers use their gut instinct and experience when making decisions.

> "I think the biggest challenge is that you don't dare to make decisions based on analytics. [...] People do not dare to make enough use of information." -P4

However, if there is motivation and willingness to make data analytics-based decisions, the lack of expertise can be an obstacle. It is challenging to integrate data and analytics into decision-making and act based on analyses. Related to this, lack of strategy was an essential obstacle. In many cases, data-driven decision-making is not part of the online retailer's strategy. It means that conclusions are based on speculation, not facts.

> "There is easily too much data, making it easier to do it (decisions) by using gut instinct. [...] The decision is based on guessing because you haven't been able to form a truly coherent conclusion." -P10

5 Discussion

This study has discussed the barriers to data-driven decision-making among online retailers. The study has sought to deepen the previous knowledge by considering data-driven decision-making as a process and identifying and describing the main barriers at different stages.

First, the study aimed to understand what prevents online stores from *collecting and organizing* data. The findings show that even though data collection is pictured as necessary (Pohl, Staegemann, & Turowski, 2022), especially in e-commerce, it may not appear as such to online retailers. Instead, quite surprisingly, data collection may generate prejudices and unwillingness to engage in the process. The negative attitudes can act as significant barriers to data-driven decision-making. They stall the process right from the start, and if attitudes toward data and data-driven decision-making are negative, the company is unlikely to invest in analytics. Data collection may also be omitted due to a lack of expertise and understanding. The benefits of the data are not understood, or the data cannot be collected due to a lack of skills. In terms of data organizing, deficiency of systematicity, problems in managing collected data, and information overload were identified as significant barriers. Earlier studies support these findings. It has been noted that, especially for small businesses, it may be hard to understand how to utilize data (Alford & Page, 2015) or how to organize it. In addition to attitudinal and expertise barriers, it was concluded that technical factors might also be an obstacle to data collection. E-commerce platforms nor partner companies' systems do not always support data collection and organizing. Hence, the compatibility between different platforms and systems that are included should be further investigated and improved to help online retailers' data collection and organizing.

Second, this study aimed to understand what prevents data from being *analyzed and summarized*. The findings demonstrate that analysis is often discouraged by a lack of expertise. Online retailers lack the skills to analyze the collected data. The analysis and summarization are characterized by randomness and lack of routines. The

combination of lack of time and knowledge is a significant obstacle to adopting analysis (Alford & Page, 2015). The findings of this study suggest that the analysis problems are related to a shortage of professionals. Furthermore, the findings demonstrate that analysis and summaries are not always done on relevant themes, and the results of analyses are not appropriately reported. Thus, the usefulness of the data collection and analysis process is questionable and contributes to unnecessary work done in the company. Studies indicate that insights should be communicated in an accessible format to draw implications quickly and take further actions (LaValle et al., 2011), and summaries of analysis should be adjusted to fit the company's needs and decision-makers (Hanssens & Pauwels, 2016). However, the findings show that online retailers struggle with these issues. It is suggested, in line with other studies, that managers should carefully choose the best combination of data collection and analysis for their objectives because gathering and analyzing unnecessary data is confusing and a waste of resources (Phippen, Sheppard, & Furnell, 2004; Weischedel & Huizingh, 2006; Welling & White, 2006).

Third, this study investigated what prevents companies from *synthesizing and prioritizing* the obtained information in decision-making. The findings show that online retailers lack knowledge of synthesizing different analyzes and information. Also, the information obtained through the various data collection and analysis stages may not be prioritized in decision-making. Routines and existing habits often limit the utilization of data analytics findings. Based on the findings, the lack of strategic planning is one of the fundamental barriers that prevent the practical usage of data analytics in decision-making. Despite many scholars (e.g., Weischedel & Huizingh, 2006; Chaffey & Patron, 2012) have noted that a solid metrics system has to be linked to both business and marketing objectives, the findings suggest that data-driven decision-making is not always a part of the online retailer's strategy and conclusions. Decisions are not based on data-driven facts. Decisions can be relatively unstructured and based on the manager's previous experience and intuition. It has been argued that the adoption of data analytics requires strategic decisions (e.g., involving staff in the implementation and selecting appropriate technology) to fully achieve its potential (Kohli & Melville, 2019). Likewise, the findings of this study highlight the importance of strategic decision-making. Doing analytics without a clear business objective does not bring apparent benefits (LaValle et al., 2011). Data collection and analysis will lack the ultimate purpose and basis if analytics is not integrated into the retailer's strategy. Online retailers should carefully

choose the best combination of metrics for their specific business objectives (Phippen, Sheppard, & Furnell, 2004; Weischedel & Huizingh, 2006; Welling & White, 2006).

This study has briefly discussed the barriers to data-driven decision-making among online retailers. To sum up, the findings are similar to those presented by earlier studies: lack of resources and skills (Chaffey & Patron, 2012), low-quality data, inappropriate data analytics tools (Ghasemaghaei, Ebrahimi, & Hassanein, 2018), and the poor involvement of top managers and lack of supportive organizational culture (Germann, Lilien, & Rangaswamy, 2013; Maxwell, Rotz, & Garcia, 2016) are among the central obstacles in the deployment of data analytics. Future studies are encouraged to further the investigations presented in this study. All the stages included in the data-driven decision-making process and the barriers occurring at the different stages should be more carefully investigated.

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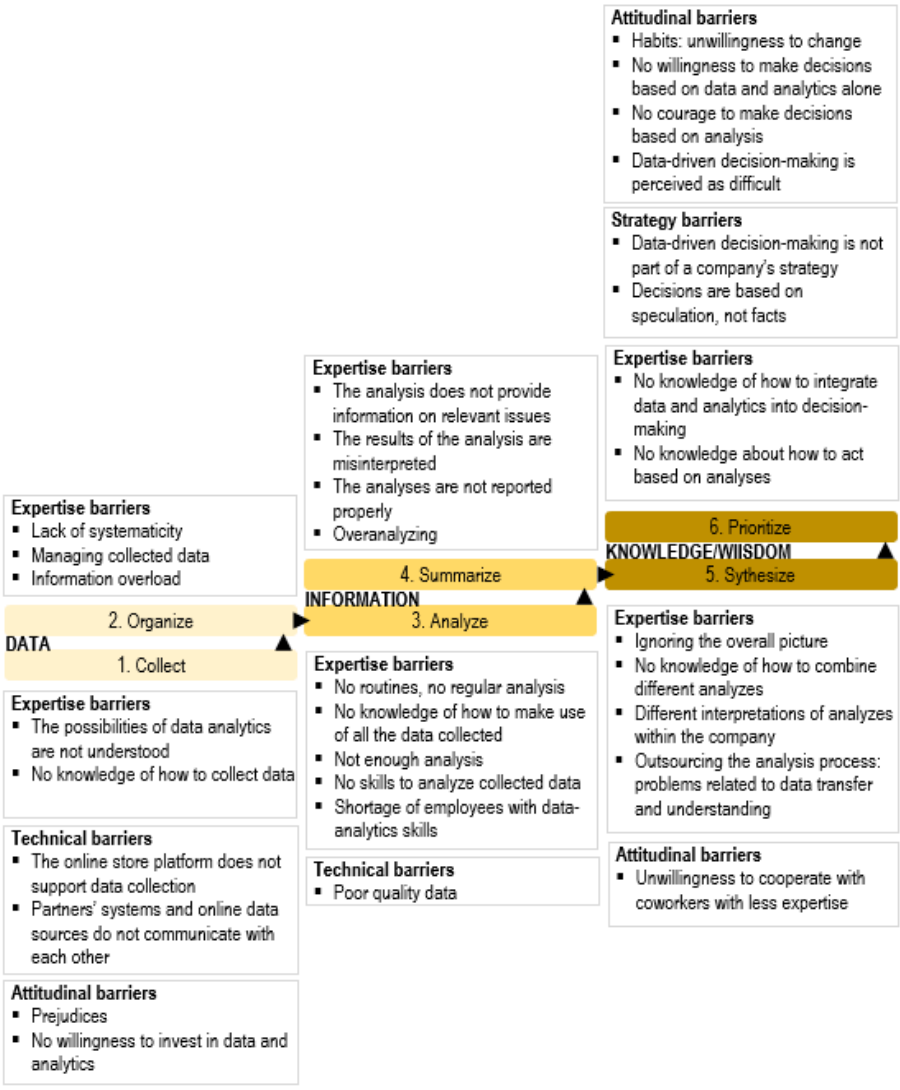
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Appendix 1: Description of the study participants

Participant	Experiece with E-commerce (years)	Current job title	Main areas of expertise / curret job	Main industry
1	12	CEO	All tasks related to the management of an online store, especially marketing	Leisure producs
2	6	Marketing technology manager	Digital marketing	Leisure products
3	4	E-commerce manager	All tasks related to the management of an online store	Clothing
4	10	Entrepreneur, sales and marketing director	Marketing	Online store implementation services
5	4	Web analyst	Marketing analytics	Management consulting
6	4	Analytics expert	Data analytics and visualization	Advertising agency
7	>20	Head of digital	Online business operations	Leisure products
8	4	CEO	All tasks related to the management of an online store	Leisure products
9	4	User acquisition manager	Customer acquisition	Games
10	>10	CEO, online retailer (4 stores), board professional, consultant	All tasks related to e-commerce	Multiple, e.g., leisure & pet products

Appendix 2: Summary of findings



UTILIZING ALGORITHMS FOR DECISION MINING DISCOVERY

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Abstract Organizations are executing operational decisions in fast changing environments, which increases the necessity for managing these decisions adequately. Information systems store information about such decisions in decision- and event logs that could be used for analyzing decisions. This study aims to find relevant algorithms that could be used to mine decisions from such decision- and event logs, which is called decision mining. By conducting a literature review, together with interviews conducted with experts with a scientific background as well as participants with a commercial background, relevant classifier algorithms and requirements for mining decisions are identified and mapped to find algorithms that could be used for the discovery of decisions. Five of the twelve algorithms identified have a lot of potential to use for decision mining, with small adaptations, while six out of the twelve do have potential but the required adaptation would demand too many alterations to their core design. One of the twelve was not suitable for the discovery of decisions.

Keywords: decision management, decision mining, algorithms, knowledge discovery.

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1 Introduction

Organizations are executing decisions in fast changing, sometimes unexpected, environments (Smirnov et al., 2009). This increases the necessity to manage these operational, high-volume, decisions, which is referred to as decision management. Decision management consists of a set of tools and techniques that allows businesses to create, validate, execute, monitor and improve decisions(Flexrule, 2021; Smit & Zoet, 2018; Von Halle & Goldberg, 2010; Zoet, 2014) and aims to improve the intelligence of business operations by developing and improving fast, consistent and precise decisions. In the past decade, decisions and underlying business logic are increasingly seen and managed separately from other aspects of an information system (Smit & Zoet, 2018; Zoet, 2014). This is in line with the separation of concerns that argues that componentization reduces complexity and enhances comprehensibility (Parnas, 1972). Separation of concerns has become a best practice in information technology architecture over the years (van der Aalst & Basten, 1997; Versendaal, 1991; Weske, 2012).

Due to the separation of concerns, many information systems store relevant process or decision data separately in some structured way (van der Aalst et al., 2012; Von Halle, 2001). For example, Business Process Management Systems register the start and completion of events, and ERP systems event log all transactions and mutations. Van der Aalst (2005) used these outputs, which are called event logs, for process mining. Process mining uses machine learning and data mining techniques to discover, conform and enhance business processes within organizations (van der Aalst & Weijters, 2005). Process mining aims to make unexpressed knowledge explicit and to facilitate a better understanding of the process (van der Aalst et al., 2012). One of the techniques used within process mining is Decision Point analysis. This technique aims to "detect data dependencies that affect the routing of a case" (Rozinat & Aalst, 2006). Decision Point analysis mines 'sequencing patterns' from a process viewpoint but leaves out the derivation patterns within decisions as it is focused on a single decision point. Therefore we consider such analysis techniques to operate from a process focused viewpoint (De Smedt, Vanden Broucke, et al., 2017; Leewis et al., 2020). However, in practice, decisions are often dependent on each other's output, which makes a Decision Point analysis less suitable for analyzing how decisions are related to each other and their implementation in the underlying business logic.

Recent studies show the need for the decision focused viewpoint (De Smedt, Vanden Broucke, et al., 2017; Leewis et al., 2020). Decision mining is a rather novel technique, which is defined as: "*the method of extracting and analyzing decision logs with the aim to extract information from such decision logs for the creation of business rules, to check compliance to business rules and regulations, and to present performance information*" (Leewis et al., 2020). Previous studies indicate that the decision focused viewpoint is necessary to advance in decision mining (De Smedt, Vanden Broucke, et al., 2017; Leewis et al., 2020). While various techniques are presented for decision mining from a process viewpoint (De Leoni & van der Aalst, 2013; Mannhardt et al., 2016; Rozinat & Aalst, 2006), only a few techniques are proposed for decision mining from a decision viewpoint. De Smedt et al., (2017) and Leewis et al., (2020) proposed examples of four algorithms for the discovery of decisions, all of which are classification algorithms as these algorithms are based on pattern recognition (Duda et al., 2001). Therefore, in this study, we focus on classification algorithms, with a focus on pattern recognition, only. Further, we try to identify requirements for decision mining techniques and map these to available algorithms found in the body of knowledge. This leads to the following research question we aim to answer in this paper: *Which classification algorithms are applicable for decision mining to discover decisions from structured data*? We do this by identifying requirements for the selection of appropriate classification algorithms through six semi-structured expert interviews. Based on the results, the body of knowledge is analyzed on the applicability of available algorithms resulting in the presentation of an overview of applicable algorithms for decision mining.

The remainder of the paper is structured as follows: The next section consists of a background and related works on decision mining and its ongoing evolution. This is followed by the research method. Next, the data collection & analysis is discussed. Then, the results are presented. Lastly, the conclusion and discussion are presented, together with future research directions.

2 Background & Related Work

Decision management manages the decisions and underlying decision logic for an organization. A decision is defined as: "The act of determining an output value from a number of input values, using decision logic defining how the output is determined from the inputs." Furthermore, decision logic is defined as: "a collection of business

rules, business decision tables, or executable analytic models to make individual business decisions". There are multiple ways for an organization to discover decisions and the underlying decision logic (Etikala & Vanthienen, 2021). The most common way is to acquire knowledge from domain experts and manually model the gained information to decisions and the underlying decision logic. However, many other sources exist to gather decisions and the underlying business logic such as event logs, text documents, and decision logs (Etikala & Vanthienen, 2021). These sources can be used to automatically discover the decisions and underlying decision logic, which minimizes the cost and time spent on manual modeling with the help of domain experts. The automatic retrieval of decisions and decision logic from event logs, decision logs, or case data is referred to as decision mining.

Decision mining aims to extract and analyze decision logs to discover, check the conformance of, and improve decisions and decision logic (Leewis et al., 2020). De Smedt et al. (2017) created a decision mining quadrant with four types of decision mining identified in literature. The first two types are the Data-First approach and Control flow first approach. They both focus on data attributes of single instances, or the sequential parts of the instances (De Smedt, Vanden Broucke, et al., 2017), see for example the work of van der Aa (2016) and Petrusel (2010). The output of these approaches is usually represented in Petri net models and focuses on sequences. The third type of decision mining is decision-annotated process mining. In this type, control flow data is used to determine the structure of the process as a first step. The second step is to use the instance attributes to define where data had impact on the workflow. This approach uses fixed decision points in an event log instead of looking for decision points throughout the model. The fourth and last type of decision mining is Decision-aware control flow, which focuses on the decision itself first, instead of the process. De Smedt et al (2017) argues that there is a gap in knowledge on the fourth type, because the focus on mining decisions is usually fixed on using event log data only.

The mining of decisions is done by using algorithms. An algorithm is a set of steps that are followed in order to solve a (mathematical) problem or to complete a computer process (Merriam-Webster, 2021). Within data mining, classification algorithms are used to place data into preset categories, which is a form of pattern recognition (Duda et al., 2001). There are different types of classification algorithms, e.g., Decision trees, K-Nearest Neighbor, Random Forest, Support Vector

Machines, Bayesian Classifier, and Artificial Neural Networks (Aggarwal & Zhai, 2012; Wu et al., 2008). All algorithms have several subtypes and specific implementations of algorithms are available. De Smedt et al (2017) already proposed five classification algorithms for decision mining with a decision focused viewpoint, namely: 1) decision trees, 2) neural networks, 3) support vector machines, 4) random forest, and 5) time series analysis. However, no further explanation is provided about the suitability of these algorithms. Therefore, we argue that the body of knowledge would benefit from further exploration about the suitability of these classification algorithms for decision mining with a decision focused viewpoint.

To be able to conduct proper algorithm selection for a given problem and its context we need to use appropriate requirements. The concept of requirements is very broad, and many types exist with each their distinct differences, looking at the software engineering domain on itself, e.g., functional requirements, non-functional requirements, and constraints (Sommerville & Sawyer, 1997). Adding to this, requirements and their elicitation, formulation and management has been researched in detail in the past decades (Cziharz, 2015; Lucassen et al., 2016; Zowghi & Coulin, 2005). To narrow the selection in favor of feasibility of this study, we choose to identify functional requirements and non-functional requirements with regards to the algorithm selection in this study. Therefore, both types are addressed in the interview protocol used in the empirical phase of this study. To ensure the results in this study are properly interpreted we provide a definition of both requirement types. A functional requirement is defined as "a function that a system (...) must be able to perform" (IEEE, 1990). A non-functional requirement is defined as "describe the nonbehavioral aspects of a system, capturing the properties and constraints under which a system must operate" (Antón, 1997). We utilize these requirement types due to two reasons. The first reason is that both requirement types, as well as their combination, represent the concept of quality very well (Chung & do Prado Leite, 2009; Glinz, 2007). The second reason is that both types are very recognizable to IS/IT practitioners and are in use for over two decades as well as being researched extensively in the past (Glinz, 2007).

3 Research Method

The goal of this study is to explore currently available classification algorithms and analyze their usefulness with regards to decision mining. To select an appropriate research method, the maturity of the research field must be taken into account. Based on the work of Edmonson and McManus (2007), research field maturity can be defined along a continuum of nascent, intermediate, and mature archetypes. Given the fact that the separation of the 'decision management' concern is considered and researched only in the last few years compared to other concerns such as processes, user interfaces, and databases, one could say that the research field maturity of decision management is nascent. This is further acknowledged in other recent studies focusing on decision mining (De Smedt, vanden Broucke, et al., 2017; Leewis et al., 2020). Therefore, our research method should focus on establishing new constructs and underlying relationships by using qualitative research methods that are more appropriate for gathering data via open-ended inquiry (Edmondson & Mcmanus, 2007).

To answer the research question, the study is divided into three research phases. The first phase comprises the identification of classification type algorithms that can mine decisions from structured data, in the body of knowledge through a literature search. The second phase comprises the empirical part of this study in which six experts from the field are interviewed using a semi-structured approach in order to establish which classification algorithms are usable for decision mining. We use interviews as a method and not literature because, as addressed earlier in this paper, the current body of knowledge almost solely focuses on decision mining from a process perspective (i.e., decision point analysis). The third phase comprises the evaluation of the identified classification algorithms against the identified requirements, to establish which classification algorithms are useful for decision mining.

4 Data Collection & Analysis

The data collection for this study is separated into three phases: 1) the identification of the classification algorithms, 2) the semi-structured interviews for requirements gathering, and 3) the evaluation of the classification algorithms against the requirements.

4.1 Phase one: identification of classification algorithms

To identify classification algorithms we conducted a scoping review (Paré et al., 2015). To ground our scoping review we address the search strategy and steps to extract relevant algorithms. The first step comprised the query identification. To identify relevant queries we looked at the scope and goal of this study, which in this case is identifying classification algorithms that could extract decisions. Based on this goal the following search term was used using google scholar: " 'classification algorithm' AND 'decision OR rules' AND 'data mining' ". We used Google scholar as the main search database due to the fact that it has a higher coverage compared to other search engines (Amara & Landry, 2012; Franceschet, 2010; Harzing & Alakangas, 2016; Wildgaard, 2015). The exclusion criteria used for the scoping review were: 1) the source must be written in English to be included, 2) the source must be available via the internet to be included, and 3) the algorithm has to have an output regarding a decision, e.g., a rule.

4.2 Phase two: semi-structured interviews for requirements gathering

Data collection for this phase was conducted between September 2019 and January 2022. We interviewed six experts on algorithms and/or decision mining. Four have an international scientific background and two have an commercial background. Of the four scientists, three are full professors and one is an assistant professor at a university. The two participants from the commercial sector have the following roles: 1) assistant manager at a data & analytics department and 2) managing data scientist. During the interviews, an interview protocol was used to help understand what the requirements are. The interview protocol consisted of the following questions: 1) What is decision mining?, 2) Which algorithms for decision discovery do you know and which do you already apply?, 3) What are the main considerations to take into account when developing algorithms for the discovery of decisions?, and 4) What are the most important requirements for such an algorithm?

All interviews were fully transcribed. Thematic coding was used to analyze the semi-structured interview transcriptions. A coding scheme was created before the analysis. The following attributes were coded: 1) Functional requirements, 2) Non-functional requirements, 3) Rationale, and 4) Algorithms.

4.3 Phase three: evaluation of classification algorithms against requirements

For the evaluation phase, two rounds were organized and multiple research team members independently evaluated the results of the previous two phases, in order to improve the validity and reliability of the results of phase three. In the first round, three research team members independently evaluated the identified algorithms against the identified requirements. They evaluated the core mechanisms of the algorithms and not the potential the algorithm has with modifications. In the second round, one of the members of the first round together with a research team member that has not participated in the first round needed to reach consensus whether a requirement has been met by the identified algorithm, based on the results of the first evaluation round. We do this to decrease the chance of interpretation error or bias occurring that could have affected the results, thus establishing high inter-rater reliability (Armstrong et al., 1997).

5 Results

The scoping review and interviews resulted in twelve relevant classifier algorithms that could potentially be used for decision mining. The identified algorithms are described in table 1.

Table 1: Found classifier algorithms

C4.5	The C4.5 algorithm is an improvement of ID3 algorithm developed by Quilan Ross. It can handle attributes with different costs, can handle training data with missing attribute values and can both handle continuous and discrete attributes (Salzberg, 1994).
CART	CART is an abbreviation for classification and regression trees and was introduced in 1984 by Breiman. It can build both classifications as well as regression trees. It is based on the same algorithm as C4.5, but it is unique due to the fact that it also uses regression analysis (Kumar, 2011).
J48	J48 is a java implementation of the C4.5 algorithm and is a classification algorithm that generates decision trees based on rules (Franco et al., 2019). The J48 algorithm has additional features compared to C4.5, including decision tree pruning derivation and the derivation of rules.

Artificial Neural Network	Neural networks provide models of data relationships through interconnected neurons that accept inputs, apply weighting, and feed the output to another neuron. It is an iterative process where different 'layers' of neurons are passed to deliver the desired outcome. A neural network can model data that has nonlinear relationships between variables and it can also handle interactions between variables (Wang, 1994).
Naïve Bayes classifier	A naive bayes classifier assumes that a particular feature is independent of any other feature. It does not take into account any possible correlations between other features and thus does say that each feature contributes independently to the probability of an outcome (Domingos & Pazzani, 1997).
K-means algorithm	K-means clustering is a type of unsupervised learning, which is used when you have unlabeled data. The goal of this algorithm is to find groups (clusters) in the data. Data points are clustered based on feature similarity (Krishna & Narasimha Murty, 1999).
Apriori algorithm	Apriori is the first algorithm that was used for frequent itemset mining. It is used to find frequent association rules from datasets (Agrawal & Srikant, 1994; Wu et al., 2008).
Trace clustering	the event log is split into homogeneous subsets and for each subset a process model is created (Song et al., 2009).
Random Forest	A random forest constructs multiple decision trees and the output of a random forest is the class selected by most trees (Tin Kam Ho, 1995). They are mostly used for predictions as their accuracy is generally higher than decision trees.
Fuzzy decision tree miner	A fuzzy decision tree miner deals with uncertainty by permitting a gradual assessment of the membership of elements in relation to a set (Rokach & Maimon, 2007). This means that it can distinguish different values from an attribute. For example, the time of day can have the values morning, evening and night.
Adaboost	AdaBoost is an ensemble learning method that was initially created to increase the efficiency of binary classifiers. AdaBoost uses an iterative approach to learn from the mistakes of weak classifiers, and turn them into strong ones (Schapire, 2013).
Support Vector Machines	Support Vector Machines are supervised learning models that analyze data for classification and regression analysis (Farhat, 1992).

The interviews were coded using the coding scheme presented earlier, which resulted in seven requirements for decision mining discovery. Six of the requirements are functional requirements and one is non-functional, see table 2.

Table 2: Requirements for decision mining

ID	Requirement	Type	Example coding
1	An algorithm must design rules from an event- or decision log	FR	"That's one form and then there are forms where the two come together a bit more where from a data log you not only solve, let's say one classification problem, but also try to include the hierarchy of decision"
2	An algorithm must extract one or more decisions from an event- or decision log	FR	"Not just a classification with some variables and then one set of outcomes, but a full decision structure with the top decision and some sub-decisions with information items. Also the rules must be included such that a whole DMN model can be generated."
3	The algorithm must use structured data	FR	"Because nobody writes anything structured on there. That's just documents, all very difficult..."
4	An algorithm must find a derivation pattern to create a decision model	FR	"So looking purely at the data and trying to fully derive that model."
5	An algorithm must find multiple decisions in the dataset	FR	"Often, if you use a larger event log, you may have trouble to find multiple rules in the dataset ..."
6	The output of an algorithm must be explainable and comprehensible by Subject Matter Experts	NFR	"When it comes to properly understanding why a business rule is a business rule, then you have a very different kind of use of an algorithm. Then, transparency is very important,"
7	A 'black box' algorithm must have a comprehensible decision visualization (e.g., Decision Model and Notation)	FR	"... that those algorithms have is that they are usually black boxes, [...]. If you take a neural network, and you cannot really understand which rules are made for the output."

The algorithms, with the explanation and the requirements, were mapped by three experts, see table 3. Each requirement is mapped to an algorithm with one of the following codes. "Y" fulfilled the requirement completely, "N" does not fulfill the requirement, "P" does fulfill the requirement in part. "P*", does partly fulfill the requirement but could be easily adapted to fulfill it completely, and NA if the requirement does not apply to the algorithm, e.g., a transparent algorithm is never a black box.

Table 3: Mapping of algorithms against requirements

Algorithm / Requirement ID	1	2	3	4	5	6	7
Fuzzy decision tree miner	**Y**	**Y**	**Y**	**P***	**Y**	**Y**	**NA**
C4.5	**Y**	**Y**	**Y**	**P***	**Y**	**Y**	**NA**
CART	**Y**	**Y**	**Y**	**P***	**Y**	**Y**	**NA**
J48	**Y**	**Y**	**Y**	**P***	**Y**	**Y**	**NA**
Apriori algorithm	**Y**	**Y**	**Y**	**P***	**Y**	**Y**	**NA**
Random Forest	**N**	**Y**	**Y**	**P***	**N**	**Y**	**NA**
Adaboost	**N**	**Y**	**Y**	**P***	**N**	**Y**	**NA**
Naive Bayes classifier	**Y**	**Y**	**Y**	**P***	**Y**	**N**	**NA**
k-means algorithm	**N**	**Y**	**Y**	**P***	**N**	**N**	**NA**
Artificial Neural Network	**N**	**Y**	**N**	**P***	**Y**	**N**	**N**
Support Vector Machine	**N**	**Y**	**Y**	**P***	**N**	**N**	**N**
Trace clustering	**N**	**N**	**Y**	**N**	**N**	**Y**	**NA**

6 Conclusion

The goal of this research was to answer the following research question: *Which classification algorithms are applicable for decision mining to discover decisions from structured data*? We collected relevant algorithms from a literature review and conducted interviews to find functional and non-functional requirements. The algorithms and requirements were mapped by experts. This research shows that all found classifier algorithms are suitable. However, none of them are directly applicable to be used for the discovery of decisions for decision mining. Five of the twelve algorithms have a lot of potential due to the fact that only one part has to be adapted. The part that has to be adapted is the discovery of derivation patterns between decisions. The five algorithms are C4.5, CART, J48, Fuzzy decision miner, and apriori algorithm. These algorithms can mine indivudal decisions, but cannot find the relations

between decisions. C4.5, CART, and J48 show the same answers for the requirements. This is explainable as they are all based on the ID3 algorithm. Some algorithms show potential, but a lot of work has to be done. For example, the Random Forest algorithm, as this algorithm has to change its core mechanics to be able to output rules. The advantage of a random forest is using multiple decision trees for predicting an outcome, which could not be used for decision mining as the main focus for decision mining discovery is extracting rules from event- and decision logs. The only algorithm that has no potential is trace clustering. Trace clustering is based on finding sequences, while decisions primarily are focused on derivation patterns.

7 Discussion & Future Work

In this study, we identified twelve classifier algorithms that could be used for discovering decisions. However, like every study, this study has limitations that should be discussed.

The first limitation is that we solely included publicly available algorithms, which limits the selection in a way that algorithms from the commercial domain are not included. These algorithms are often integrated within commercial software or when available separately, not entirely documented to be analyzed like required in this study. Although, to our best knowledge, we think that we included a selection of algorithms that are well known and documented. Of course, it could be the case that potentially relevant (commercial) algorithms for decision mining are not included and our overview is not generalizable. Future research could therefore take into account how suitable algorithms from the commercial domain rank up in terms of suitability for decision mining against the selection of algorithms analyzed and discussed in this study.

The second limitation concerns the focus of the study towards algorithms that support the 'discovery' of decisions. Decision mining also comprises the 'conformance' and 'improvement' of decisions, which are not included in this study. This is because the goal of 'conformance' (checking discrepancies between the decision log and the decision model) and 'improvement' (extending or improving the decision model based on the decision logs) of decisions is different than that of 'discovery' of decisions, thus classification type algorithms are not suitable.

Additionally, only data and process mining algorithms were included in this study, which is in line with earlier research on the relevancy of such algorithms for decision mining (de Jong et al., 2021). Future research should focus on similar explorations such as done in this study for the 'conformance' and 'improvement' of decisions.

The third limitation entails the research methods used in this study. Although we used a rigorous approach to identify and select algorithms in the first phase, it could be the case that newer and less known classification algorithms were unintentionally left out during the selection. Concerning the second phase one could argue that a limited selection of experts was utilized to derive a set of requirements for the selection of appropriate algorithms as well as that the abstraction of the requirements could be set-up differently. Currently, not many decision-mining researchers and experts could be identified, which is in line with the low maturity of the research field of decision mining. Additionally, the outcomes of the semi-structured interviews are in line with the body of knowledge on decision mining. For the third phase we used a research team to determine the scores for each requirement, until consensus was reached, which mitigates personal bias of individual research team members. Future research should focus on including more participants for both the second and third phase so that the generalizability of the results can be increased.

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A Framework to Identify Data Governance Requirements in Open Data Ecosystems

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Abstract Open data and open data ecosystems (ODEs) are important for stakeholders from science, businesses, and the broader society. However, concerns about data sharing and data handling are significant adoption barriers of ODEs that reduce stakeholder participation and thus the success of the initiative. Data governance (DG) is proposed as solution, but requirements of the three stakeholder groups combined are not clear and especially how they can be integrated in one DG concept. This paper develops a framework, supporting elicitation of DG requirements in ODEs. The framework builds on a series of stakeholder workshops and literature research resulting in DG requirements and DG mechanisms. The resulting framework includes five main dimensions: (1) data usability, (2) ethical and legal compliance, (3) data lineage, (4) data access and specified data use, and (5) organizational design.

Keywords: open data, ecosystem, data governance, requirements, framework.



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1 Introduction

In recent years open data has become a valuable resource in a digitized world. Data is considered open when it " […] can be freely used, modified, and shared by anyone for any purpose"(Open Knowledge Foundation, n.d.). Open data can enhance transparency and public engagement for public institutions, facilitate innovation and development of new products and services in businesses, or can enable research by providing combined open data sets (Janssen et al., 2012). Based on these expected benefits, governments worldwide increasingly started to propose and implement open data platforms (United Nations, 2020). Promising examples are the European Open Science Cloud (EOSC) and Gaia-X aiming to funnel data from national or regional initiatives into larger combined infrastructures (Bonfiglio, 2021; European Commission, 2019).

Despite the potential of open data and open data ecosystems (ODEs), there are several barriers that can reduce the willingness of stakeholders to participate and to share data. Primarily, these barriers are legal concerns, knowledge protection concerns or technical concerns (Zeiringer and Thalmann, 2021). Such barriers are especially important in co-opetitive settings between science and industry (Kaiser et al., 2020). In this regard, data governance (DG) is frequently proposed to mitigate these barriers in ODEs. So far research on DG in ODEs focussed on specific stakeholder groups such as science, society, or business. Requirements for DG involving all stakeholder groups and finding a suitable consensus is missing so far. The maximal benefit of ODEs, however, can only be realized if all three groups participate in ODEs. Thus, the paper aims to clarify the following research question:

How to identify data governance requirements for different stakeholder groups in ODEs?
Therefore, we conducted a study in a regional ODE focusing on data sharing and collaboration between science, business, and society.

2 Background

Data ecosystems can be defined as a "set of networks composed by autonomous actors that directly or indirectly consume, produce or provide data and other related resources" (Oliveira & Lóscio, 2018). These actors can be divided into platform owners and users. Platform users can be subdivided into a supply side (e.g., data

providers or data analysts) and a demand side (e.g., data consumers) (S. U. Lee et al., 2018a). The DG requirements of platform users are the focus of this paper, since the fulfilment of their requirements ultimately determines if a data platform will be used or not. One promising way to identify DG requirements of stakeholders is to investigate the barriers that prevent participation in ODEs. Beno et al. (2017) identified privacy and security issues, missing economic and strategic incentives, legal constraints, and technical difficulties as core barriers. To mitigate some of these barriers, DG can be implemented in ODEs. DG refers to the allocation of decision rights and accountabilities for data related decision-making in organizations (Khatri & Brown, 2010). The effects of well implemented DG include the reduction of data related risks and positive impacts on organizational performance (Gregory, 2011). Abraham et al. (2019) proposes structural mechanisms (e.g., roles and responsibilities), procedural mechanisms (e.g., standards, monitoring), and relational mechanisms (e.g., communication, training) as core elements of DG frameworks. For each of these dimensions concrete DG mechanisms matching the requirements of all stakeholder groups need to be defined. Several studies explored DG requirements in the context of ODEs or other data ecosystems that can serve as a benchmark for the development of DG (see e.g., Al-Ruithe & Benkhelifa, 2017; D. Lee, 2014; S. U. Lee et al., 2017; Van Den Broek & Van Veenstra, 2015; Welle Donker & van Loenen, 2017; Wende & Otto, 2007).

These studies provide an insight into the requirements of ODEs but do not differentiate between ODEs with different stakeholder groups or only allow to indirectly assess the DG requirements through intermediate factors or configurations. The indirect assessment is problematic for two main reasons: (1) Contingency factors or configurations represent generalizations that are a useful starting point but can by design not depict the reality of every individual case. (2) Indirectly obtaining DG requirements excludes stakeholders from the development process of DG, which can lead to less trust, motivation, and participation of stakeholders compared to decentralized approaches (S. U. Lee et al., 2018a). A DG framework is therefore needed that allows developing ODEs to directly assess DG requirements from their individual stakeholder groups. Such a framework is to our best knowledge not yet available, although existing frameworks can serve as base for its development. Showing the strengths and shortcomings of those existing frameworks is not withing the scope of this paper.

3 Method and Procedure

A three-stage study (see table 1) was conducted in a regional ODE, that aims to develop a reference model for collaborative data use and to foster data cooperation between industry and science. Overall, 31 experts in data-related domains and had professional experience in Styrian universities and research facilities, public administrations, at global players in the automotive industry and pharma industry, insurance companies, and consulting agencies participated. Most of the stakeholders were in leading or top-level positions.

Table 1: Overview of the research process

	Stage 1	**Stage 2**	**Stage 3**
Method	Requirement workshops	Literature research	Validation workshop
Details	16 stakeholders from 3 domains	DG mechanisms from 26 sources	16 stakeholders from 2 domains
Results	DG requirements	DG framework	Validated & prioritized DG framework

Stage 1 - Requirement workshops: First, DG requirements were identified during three separate online workshops in March and April 2021 for stakeholders from science (n=6), public institutions (n=4), and business (n=6). Each workshop consisted of brainstorming, clustering, prioritization, and an in-depth discussion regarding the DG requirements. The workshops were audio-recorded, transcribed and analysed using the thematic analysis by Braun and Clarke (2006).

Stage 2 - Literature research: A literature research was conducted to extend the requirements from stage 1 into a DG framework. As a result, 26 papers were identified and analysed using the approach of Braun and Clarke (2006). Each sub-requirement was structured into three levels of requirement fulfilment. Thus, a DG framework was developed that combines the empirically identified DG requirements with corresponding DG mechanisms obtained in the literature.

Stage 3 - Validation workshop: To validate and prioritize the developed DG framework, an online workshop with 16 participants was conducted in December 2021. The identified main DG requirements were discussed and prioritized the by distributing

10 'priority points' to one or more requirements. Furthermore, they defined their minimum level of requirement fulfilment. Two final questions investigated the overall importance of DG in ODEs and the influence of the designed DG framework on their willingness to participate.

4 Results

The results of our study are five main stakeholder requirements for DG in ODEs: (1) data usability, (2) ethical and legal compliance, (3) data lineage, (4) data access and specified data use, and (5) organizational design (see table 2). Out of the sixteen stakeholders only fifteen participated in the prioritisation. All fifteen of them voted for the requirement 'data usability' and allocated 43 (28,7%) points to this requirement, more than to any other DG requirement. Also, all 15 voters voted for 'ethical and legal compliance' and assigned 35 (23,3%) priority points. The other requirements were not prioritized by all voters.

Table 2: Overview, definitions, and prioritisation results of the DG requirements (n=15)

	Requirement definition	**Priority** sum=150	**Unique voters**
Data usability	Users can use the data with the provided recourses for the allowed use cases.	**43** (28,7%)	15
Ethical & legal compliance	Legal regulations are followed, and data is used ethically, fairly, and transparently.	**35** (23,3%)	15
Data Lineage	Every transformation or alteration of data, from data origin to the current form, is traceable.	**31** (20,7%)	13
Data access & specified data use	Data providers specify, who can access their data under which conditions, for which purposes and what are allowed use cases.	**28** (18,7%)	14
Organizational design	Decision rights and responsibilities are clearly specified within an organizational structure.	**13** (8,7%)	10

4.1 Data usability

The usability of the provided data is key feature of an ODE, as one stakeholder expressed "[…] it is important, that there is a process in place to ensure, that the provided data will enter the system with controlled quality, regarding completeness, plausibility and in the end also data quality. This is a crucial starting point for all the data processing and the conclusions drawn from the provided data [E1]". The interviewee highlights the relationship between quality of input data and the outcome of analytic projects and that "this is a crucial starting point". In addition to the data quality of the data set itself, interviewees mentioned suitable data formats as very important from a technical perspective as well as metadata to understand the data set. Building on this, other stakeholders highlighted that this is not only true for technical data quality measures, but also for more qualitative measures such as relevance and up-to-dateness. See table 3 for details of the main requirement 'data usability'.

Table 3: DG mechanisms for 'data usability' according to literature research

	Level 1	**Level 2**	**Level 3**
Data quality	Quality standards	Level 1 + data cleaning	Level 2 + stewards and data enrichment
Metadata	Non-standardized	Standardized in the data platform	Standardized for different domains
Data formats	One format chosen by data providers	formats chosen by data providers	formats according to user needs
Data updates	No updates	Regular updates + versioning	Near-time updates + versioning

Data Quality - Level 1: Data quality can be ensured by continuously measuring and assessing the uploaded data according to data quality standards and metrics (DAMA, 2010; Otto et al., 2007). Level 2: The data platform can offer additional services to further improve data quality. A data cleaning service can be implemented to correct errors, standardize information, and validate uploaded data (Comerio et al., 2010). Level 3: The introduction of data stewards that are responsible for the quality and use of data can further improve data quality (DAMA, 2010). An additional data enrichment service can add value to existing data sets by incorporating data from other data sources (Comerio et al., 2010).

Metadata - Level 1: Metadata can be implemented without standardized meta data elements such as free texts (Welle Donker & van Loenen, 2017). Level 2: Preferably, metadata and data documentation is standardized throughout the data platform (Welle Donker & van Loenen, 2017). Level 3: Commonly agreed upon metadata standards are used that are valid for certain domains such as e.g., healthcare (Welle Donker & van Loenen, 2017; Zuiderwijk et al., 2012).
Data formats - Level 1: A basic policy might only require data providers to provide data in a single data format of their choice (Welle Donker & van Loenen, 2017). Level 2: To further increase the usability of data, data providers can be required to offer data in different formats (Welle Donker & van Loenen, 2017). Level 3: An advanced policy can even require data providers to offer specific formats that are requested by data users (Welle Donker & van Loenen, 2017).

Data updates - Level 1: In a rudimentary implementation data providers upload data to the platform and do not update their data at any point (Welle Donker & van Loenen, 2017). Level 2: Data providers have to update data regularly (e.g., every year) and offer versioning (Welle Donker & van Loenen, 2017). Level 3: Updating data near-time and offering versioning can additionally improve data usability for data users (Welle Donker & van Loenen, 2017).

4.2 Ethical and legal compliance

General Data Protection Regulation (GDPR) was mentioned by several stakeholders, as one said: "I think it is an essential area that generally must be considered, since it won't be possible to avoid dealing with personal data [E1]". This statement highlights, that the data platform needs mechanisms to ensure the correct use and processing of personal data and to ensure compliance with the GDPR. Furthermore, the user´s ethical responsibilities while using data was highlighted. As solution the stakeholders proposed monitoring the operations in the data platform and the certification of the DG program. Thereby, it was requested that the overall technological implementation of the data platform should ensure data security and compliant use and processing of data. See table 4 for the main requirement 'ethical and legal compliance'.

Table 4: DG mechanisms for 'ethical and legal compliance'

	Level 1	Level 2	Level 3
Monitoring and audits	Done by the platform owner	Done by the platform owner and platform users	Level 2 + external certification
Compliance tools	DG is techno-logically integrated	Level 1 + automated adaptations	Level 2 + measurements and indicators

Monitoring and audits - Level 1: A basic implementation can consist of regular audits and monitoring of the DG program by the owner of the data platform (Abraham et al., 2019; DAMA, 2010; S. U. Lee et al., 2018b). Level 2: In a more decentralized setup, also the platform users audit and monitor the DG program (DAMA, 2010; S. U. Lee et al., 2018b) and thus provide a more objective and unbiased assessments (DAMA, 2010). Level 3: Certifications according to international standards like ISO/IEC 38505-1 that are assured by auditors offer the highest standard to ensure compliance (ISO, 2017; Johannsen et al., 2020).

Compliance tools - Level 1: DG controls can be technologically integrated into a data platform (Al-Ruithe et al., 2019; Gheorghe et al., 2009). These controls can ensure compliance, but are not necessarily linked to specific compliance objectives (Gheorghe et al., 2009). Level 2: Once all integrated controls are linked to explicit compliance objectives, they can automatically adapt when objectives change (Gheorghe et al., 2009). The compliance objectives can be centrally stored in a policy repository and should be adjusted according to legal and ethical requirements (Gheorghe et al., 2009). Level 3: In addition to these automated controls, compliance indicators can be implemented to automatically measure the degree of compliance of DG processes (Al-Ruithe et al., 2019; Gheorghe et al., 2009). An example for these indicators is the number of instances where personal data was not correctly anonymized (Gheorghe et al., 2009).

4.3 Data lineage

A way to trace the data and its transformations in an ODE was requested. One interviewee highlighted the importance of data lineage for the overall trust into the data platform and the provided data: "[…] it is important for those, that use the data,

to build a form of trusted environment and to make clear where data comes from [E2]". Other stakeholders stated that not only the origin of the data, but also the applied transformations are important to ensure reproducibility of research. Especially for this reproducibility the granularity of the lineage data matters since a greater level of detail enables more accurate reproduction of research results. Interviewees pointed out that this lineage information needs to be communicated very clearly to the platform users, making the access to this information an important requirement. See table 5 for details of 'data lineage'.

Table 5: DG mechanisms for 'data lineage according' to literature research

	Level 1	**Level 2**	**Level 3**
Lineage type	Input data	Level 1 + transformations	Level 2 + update lineage
Granularity	Information about data sets	Information about data sets or tuples	Information about tuples
Access	Visualisation	Level 1 + queries	Level 2 + API

Lineage type - Level 1: The lineage information clarifies from which input data given output data was derived, but does not specify which transformations were applied during the derivation process (Ikeda & Widom, 2009). Level 2: Additional lineage information can contain the transformations that were applied during the derivation process ranging from simple aggregations or algebraic operations to complex procedures using custom code (Cui & Widom, 2003; Ikeda & Widom, 2009). Level 3: An extension to level 2 can be a data lineage system, that combines lineage information of derived data (input data and transformations) with the update history of input data (Das Sarma et al., 2008). This allows data users to view different versions of derived data depending on the version of input data they select (Das Sarma et al., 2008).

Granularity - Level 1: Coarsely-grained data lineage contains information about entire data sets (Ikeda & Widom, 2009). An example can be information about the input data set or transformations that were used to produce an output data set (Ikeda & Widom, 2009). Level 2: An extension is to provide lineage by offering information about data sets and individual data-tuples (Simmhan et al., 2005). This might require the use of dataset abstractions to track data in more general forms than datasets or

tuples (Foster, 2003; Simmhan et al., 2005). Level 3: In a finely-grained setup lineage information is available about every given data-tuple (Zafar et al., 2017).

Access - Level 1: A fundamental approach can be to visualize lineage information using a derivation graph (Simmhan et al., 2005). Level 2: Additional queries on the lineage data can be offered, e.g. selecting data with specific transformations (Simmhan et al., 2005). Level 3: To complement the access through visualization and queries, application programming interfaces (APIs) can allow users to implement their own data lineage services (Simmhan et al., 2005).

4.4 Data access and specified data use

The ability to limit data access and data use is a key feature of ODEs as one managing director expressed "[…] data security is important, that it is clear how data is provided and that sensitive data stays secure inside the platform and access rights, and roles are ensured [E3]". This statement highlights how important data access control mechanisms are to ensure, that sensitive data is only available to the intended data users. Further, it was stated that the available data needs to be distributed under appropriate licenses that must be communicated clearly to the data users. Finally, data should only be used for the intended use cases since the context can have substantial influence on the possible interpretation of data. See table 6 for details of 'data access and specified data use'.

Access control - Level 1: A basic method of access control can be based on the identity or role of users (Majumder et al., 2014). In such a setup the platform owner could allow access to data depending on the role of a given user (S. U. Lee et al., 2018b; Majumder et al., 2014). Level 2: To give data providers more control about their data, they can specify access rules to their data depending on the role of a given user (Majumder et al., 2014). Level 3: A policy-based access control method can allow data providers to define individual access policies beyond identity or roles by encrypting data before data upload (Majumder et al., 2014).

Table 6: DG mechanisms for 'data access and specified data use'

	Level 1	Level 2	Level 3
Access control	By platform owner – based on user roles	By data provider – based on user roles	By data provider – based on policies
Licenses	Standard license	Licensing options	Level 2 + custom licenses
Use cases	Platform standards prohibit certain purposes of use	Data providers prohibit certain purposes of use	Level 2 + certain contexts of use are prohibited

Licenses - Level 1: The simplest solution is to define a standard license that applies to all data of the data platform and allowing users to use and combine different data sets (Martin et al., 2013). Level 2: The data platform can allow data providers to choose from a defined set of licenses that should apply to their published data (Immonen et al., 2018). Selection guidelines can be offered to guide data providers in their selection process (Alamoudi et al., 2020; Immonen et al., 2018). Level 3: In the advanced case data providers can choose from a defined set of licenses and customize those licenses (Alamoudi et al., 2020; Immonen et al., 2018).

Use cases - Level 1: The implementation of data access standards and corresponding service level agreements are a simple way to restrict data usage (Abraham et al., 2019; Al-Ruithe et al., 2019; Khatri & Brown, 2010). Level 2: In a more advanced case data providers could specify access requirements, that limit the use of their data to certain purposes (Custers & Uršič, 2016). These purposes may include social use (non-profit), professional use (for-profit) or academic use (Abella et al., 2019). Level 3: Data providers could additionally restrict the data usage to certain contexts and prohibit data recontextualization, e.g. health data can be used for diagnostics but not for health insurances (Custers & Uršič, 2016).

4.5 Organizational design

A clear definition and distribution of DG roles and responsibilities in an ODE are of enormous importance for the organizational design, as one interviewee highlighted "[…] it is simply important to know, what kind of role distribution is present in such a platform. […] It is no simple organizational task to determine, who is going to take on which role [E3]". In addition, he expressed the requirement of

platform neutrality, that should ensure that the (decision) rights of the platform users are not restricted by the platform owner. See table 7 for details of 'organizational design'.

Table 7: DG mechanisms for 'organizational design' according to literature research

	Level 1	Level 2	Level 3
Decision rights	Mostly held by platform owner	Shared by platform owner and users	Mostly held by platform users
Roles and responsibilities	Roles are implemented	Level 1+ Roles are regularly adapted	Level 2 + Training for role owners

Decision rights - Level 1: In a data platform with a centralized DG design, the data related decision rights and control are mostly held by the platform owner (Abraham et al., 2019; S. U. Lee et al., 2018b; Lis & Otto, 2021). This centralized form of DG can be simpler, but also lacks transparency and stakeholder participation (S. U. Lee et al., 2018b). Level 2: A more decentralized approach can allow data users to share some of the data related decision rights with the platform owner (Abraham et al., 2019; S. U. Lee et al., 2018b; Lis & Otto, 2021). Level 3: A fully decentralized or self-organized approach can locate most of the decision rights to the platform users and only keep core decision to the platform owner (Abraham et al., 2019; S. U. Lee et al., 2018b; Lis & Otto, 2021). This approach can lead to more transparency and stakeholder participation compared to the more central approaches of level 1 + 2 (S. U. Lee et al., 2018b). However, this approach is also complex and difficult to execute (S. U. Lee et al., 2018b).

Roles and responsibilities - Level 1: A basic implementation can define DG roles and responsibilities of the data platform (Al-Ruithe & Benkhelifa, 2017). Level 2: Additionally, the roles and responsibilities can be regularly reviewed and adapted to meet the changing requirements (Al-Ruithe & Benkhelifa, 2017). Level 3: Further, the role owners can also receive role-specific training to reduce user errors, increase productivity and increase compliance (Otto et al., 2007).

5 Discussion and Outlook

We developed a framework for DG requirement identification validated by stakeholders from science, public institutions and business. Feedback from stakeholders underlined the importance of DG in ODEs and confirmed the positive effects of well-designed DG on stakeholder participation.

The main **theoretical contribution** is the clarification of DG requirements for ODEs with the three mentioned stakeholder groups. In addition, we also provide corresponding DG mechanisms that match the identified DG requirements. This complements existing frameworks that either do not consider varying DG requirements of different stakeholder groups and matching DG mechanisms (Abraham et al., 2019; Al-Ruithe & Benkhelifa, 2017; Welle Donker & van Loenen, 2017) or only indirectly identify DG requirements through intermediary factors or configurations (S. U. Lee et al., 2017; Van Den Broek & Van Veenstra, 2015; Wende & Otto, 2007).

As the main **managerial contribution**, the newly developed framework can be used in ODEs to directly obtain DG requirements from corresponding stakeholder groups. This inclusion of stakeholders in the development process of DG can lead to more satisfaction, trust, motivation and participation of these stakeholders (S. U. Lee et al., 2018b). Fulfilling the DG requirements of different stakeholder groups can help to overcome the open data adoption barriers as described by Beno et al. (2017).

The main **limitation** of this paper is, that the developed DG framework is based on requirements of a regional ODE. Even though the framework allows to differentiate fulfilment levels, the overall DG requirements and sub-requirements might differ in other regional contexts and with different stakeholder groups. A generalization of our results was not intended but can serve as a foundation for regional or contextual adaptations. The scope of this research did not include the implementation of DG and it is therefore not possible to make claims about the practical feasibility of the proposed DG framework.

Future research should explore, how the identified DG framework and the suggested DG mechanisms can be implemented in ODEs. In this regard the perspective of Open Educational Recources in the context of internationalization (Pirkkalainen et. al, 2010) should be taken into account. Additional research is also needed to adapt the framework for other regional contexts and different stakeholder groups.

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Stages of Exercise Behavior Change in a Digital Wellness Program for Aged People: Relationship With Self-Efficacy for Exercise

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Abstract Sustained physical activity and exercise are central to healthy ageing. Yet, the majority of aged people are insufficiently physically active. Digital wellness technologies are potential in promoting exercise behaviors among aged people, but more detailed research on their potential to promote behavior change is limited. To address this gap, the purpose is to investigate how partaking in a digital wellness program influences the stage of exercise behavior change among aged people and to test whether self-efficacy for exercise can differentiate the program participants in terms of the stages of change. The investigation builds on the stages of exercise behavior change derived from the transtheoretical model of behavior change and on self-efficacy for exercise. The results suggest that partaking in a digital wellness program can be effective in promoting exercise behavior change among aged people and show that self-efficacy for exercise may differentiate aged people at different stages of exercise behavior change.

Keywords: digital wellness, wellness technology, mobile wellness application, physical activity, aged people, young elderly, transtheoretical model, stages of change, follow-up study, physical activity application.

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1 Introduction

Aged people form an important target group for actions that aim to promote physical activity (PA) and exercise behaviors. Practically all countries globally are undergoing a growth in the proportion of the older population while the life expectancy at older ages is improving (United Nations, 2019). Thus, supporting healthier ageing is increasingly important. PA and exercise have significant health benefits and contribute to the prevention of non-communicable diseases (WHO, 2020), support maintaining the ability to function, and help to protect against age-related illness and frailty (Hoogendijk et al., 2019). Despite the World Health Organization (WHO) and several national health institutes providing research-based recommendations and guidelines for PA and exercise, insufficient PA is a major global problem in all age groups (WHO, 2020). For example, in Finland, where the present study was conducted, only around one-fourth of the people over 60 years of age meet these recommendations (THL, 2019). To support healthier ageing, solutions that would help aged people in their PA and exercise behavior change are increasingly needed.

Digital wellness technologies (DWT), that is, "digital technologies that can be used to support different aspects of wellness" (Kari et al., 2021), as well as related digital wellness programs are seen as prospective solutions (e.g., Carlsson & Walden, 2017). Their potential to promote PA and exercise behaviors among aged people has been suggested (e.g., Seifert et al., 2018; Stockwell et al., 2019), but research on their potential to promote behavior change is limited. To address this gap, the purpose of the present study is to investigate 1) *how partaking in a digital wellness program influences the stage of exercise behavior change among aged people*, and to test 2) whether *self-efficacy for exercise can differentiate the program participants in terms of the stages of change*. The investigation builds on the stages of exercise behavior change (Gorely & Gordon, 2005; Marcus et al., 1992), which is derived from the transtheoretical model of behavior change (Prochaska & DiClemente, 1983), and on self-efficacy for exercise (Resnick & Jenkins, 2000).

The study contributes to the stream of research on the ability of DWTs and related programs to support PA and exercise behavior change and provides further insights on the relationship between the stages of exercise behavior change and self-efficacy

for exercise among aged people. As a practical contribution, insights for those managing digital wellness programs are given.

2 Background

2.1 Digital wellness technology use and behavior change

One of the underlying reasons for using DWTs is the expected positive effects on wellness behavior and outcomes. By using DWTs, the users are receptive to potential changes in their related behavior. Oinas-Kukkonen (2013) points out that "information technology always influences people's attitudes and behaviors in one way or another", either intendedly or unintendedly. In this idea, Oinas-Kukkonen (2013) presented the concept of behavior change support system (BCSS), defined as "a socio-technical information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception".

Different DWTs can act as BCSSs in various ways. By using DWTs, users are exposed to user experiences that can act as a stimulus for future behaviors (e.g., Kari et al., 2016a; Karppinen et al., 2016) and persuade positive or negative behavior changes (Oinas-Kukkonen, 2013). Common features that can support behavior change include, for example, feedback (e.g., Wang et al., 2016), goal-setting (e.g., Gordon et al., 2019; Kirwan et al., 2013), digital coaching (e.g., Kari & Rinne 2018; Kettunen et al., 2020), social support (e.g., Sullivan & Lachman, 2017), gamification (e.g., Kari et al., 2016b; Koivisto & Hamari, 2019), and exergaming (e.g., Kari et al., 2020; Loos & Zonneweld, 2016).

Among aged people, DWTs have been shown to be potential in supporting positive changes in wellness and exercise-related behaviors (e.g., Changizi & Kaveh, 2017; Kari et al., 2021; Larsen et al., 2019; Muellmann et al., 2018; Stockwell et al., 2019; Yerrakalva et al., 2019) as well as in related factors, such as self-efficacy (e.g., Changizi & Kaveh, 2017; Kari et al., 2022). However, users sometimes face also negative or detrimental experiences with these technologies (Rockmann, 2019). Further, the technology needs to be perceived as compatible with the user's current exercise habits (Makkonen et al., 2012).

2.2 Transtheoretical model of exercise behavior change

The transtheoretical model (Prochaska & DiClemente, 1983; 1986; 1992) is a general model of intentional behavior change. Originally, it was developed to explain changes in addictive behaviors, but has since been widely used to explain various health-related behaviors, such as exercise (e.g., Gorely & Gordon, 2005). The model illustrates the dynamic nature of behavior change and establishes that behavior change is likely to take place through a series of stages. However, instead of a linear progression, the change can be cyclical with progression and relapses between the stages (Gorely & Gordon, 2005; Prochaska & DiClemente, 1992).

The model presents three hierarchical levels that are integrated to produce behavior change: 1) five stages of change, 2) three factors assumed to influence behavior change, and 3) the context of the behavior (Gorely & Gordon, 2005; Prochaska & DiClemente, 1986). The five stages of change include Precontemplation, Contemplation, Preparation, Action, and Maintenance. The three factors assumed to influence behavior change include the processes of change, self-efficacy, and decisional balance. The context of the behavior identifies the central issue that the individual needs to overcome in order to change the behavior in question (Gorely & Gordon, 2005; Prochaska & DiClemente, 1986). The present study focuses on the five stages of change and the self-efficacy factor, which is a central determinant of exercise behavior.

Prochaska and DiClemente (1992, p. 1103–1104) define the five stages: 1) *Precontemplation,* "at which there is no intention to change behavior in the foreseeable future"; 2) *Contemplation*, "in which people are aware that a problem exists and are seriously thinking about overcoming it but have not yet made a commitment to take action"; 3) *Preparation*, "that combines intention and behavioral criteria" and in which individuals "are intending to take action in the next month and have unsuccessfully taken action in the past year"; 4) *Action*, "in which individuals modify their behavior, experiences, or environment in order to overcome their problems"; and 5) *Maintenance*, "in which people work to prevent relapse and consolidate the gains attained during action". These stages have been shown to apply also in the case of exercise and aged people (e.g., Gorely & Gordon, 2005) and are, thus, well suited to illustrate the behavior change process investigated in the present study.

2.3 Self-efficacy

Self-efficacy refers to an individual's "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" or, in other words, "the belief that one can achieve what one sets out to do" (Bandura, 1977, 1997). Bandura (1977) presents four central sources that influence an individual's self-efficacy: 1) *performance accomplishments* refer to experiences an individual gains when undertaking a new task and successfully mastering it; 2) *vicarious experience* refers to an experience of observing other individuals successfully complete a task without adverse outcomes; 3) *verbal persuasion* refers to external positive verbal feedback regarding an individual's ability to succeed in a task; and 4) *emotional arousal* refers to an individual's present state of arousal and how that influences the perceptions of being able to succeed in a task (Bandura, 1977). It is important to note that all these four main sources of influence can have either a positive or a negative influence on self-efficacy. For example, if an individual fails in a task, it can decrease self-efficacy (Bandura, 1977). Of these four, performance accomplishments have repeatedly been shown to be the most influential (McAuley & Blissmer, 2000).

Self-efficacy has a significant influence on human behavior and on individuals' actions. A person with high self-efficacy is more likely to undertake tasks that one perceives as challenging, whereas a person with low self-efficacy is more likely to avoid such tasks (Bandura, 1977; Schunk, 1990). Moreover, individuals with high self-efficacy are likely to be more successful than individuals with low self-efficacy (Bandura, 1997). This also applies in the case of exercise (McAuley & Blissmer, 2000). Indeed, self-efficacy has been shown to be one of the most important determinants of exercise behavior (Bauman et al., 2012; Trost et al., 2002; Warner et al., 2014). It has an important role in both the adoption and adherence phases of exercise: after initial mastery experiences, self-efficacy supports maintaining health-related behaviors, and helps in resuming them if facing challenges (Warner et al., 2014). Self-efficacy has been demonstrated to be a significant predictor of long-term exercise adherence (McAuley & Blissmer, 2000; Warner et al., 2014; Williams & French, 2011). This applies also among aged people (King et al., 1995; McAuley, 1993; McAuley et al., 2005). Furthermore, self-efficacy has been shown to increase as an individual moves through the stages of exercise behavior change (Marcus et al., 1992).

3 Methodology

3.1 Research setting

The present study was part of the *DigitalWells* research program, in which aged people were provided with a mobile physical activity application to use in their everyday life. The application was developed for the target group in the program and operates on the Wellmo platform (Wellmo, 2021), where the application features constitute their own entity. Wellmo supports the iOS and Android operating systems. The central features are related to tracking everyday PA and exercise. This includes, for example, features for tracking the conducted PA and exercises as well as weekly, monthly, and annual reports on these. It is also possible to import data from external services supported by the Wellmo platform, such as Google Fit, Apple Health, and Polar Flow.

The first groups of participants in the research program started in June 2019, after which new groups started continuously. The program and the present study were conducted in Finland, and the groups were recruited via the Finnish pensioners' associations. No limits except for age were set for partaking. Each group was assigned a researcher who guided the participants in taking the application into use and using it. The participants used the application in their everyday life and conducted PA and exercise according to their preferences. That is, they were not provided with any specific exercise programs to follow, but instead could freely conduct exercise how and when they preferred. The application use was free of charge for the participants, but an own smartphone was required. The local ethical committee was consulted before the start of the research program, which deemed that no separate approval was required for the conducted studies. All participants also gave a written informed consent.

3.2 Data collection and analysis

The data on the stages of exercise behavior change and self-efficacy for exercise were collected as a self-report with online surveys at two different time points: at the beginning of the program before taking the application into use (t0) and after 12 months of partaking in the program and using the application (t1). Thus, the participants in the present study consist of those partaking in the research program

and using the application for at least 12 months. For the surveys, each participant received a survey invitation link via email, and they were also provided with instructions on answering. No interim results of the analysis were presented to the participants during the study period.

The stages of change were measured by using the Stage of (exercise behavior) Change Instrument (Gorely & Gordon, 2005; Marcus et al., 1992). It places individuals into either Precontemplation, Contemplation, Preparation, Action, or Maintenance stage (Appendix A). Self-efficacy was measured by using the Self-Efficacy for Exercise (SEE) Scale by Resnick and Jenkins (2000), which assesses an individual's beliefs in their ability to exercise three times per week for 20 minutes. The SEE scale includes nine statements concerning personal confidence related to conducting exercise (Appendix B), measured on a scale of 0–10 (0 - *not confident* – 10 - *very confident*). The SEE scale also includes a total score value (0–90), which represents the overall self-efficacy for exercise. It is calculated as a sum of the responses to each statement, with a higher score indicating higher self-efficacy (Resnick & Jenkins, 2000). In the present study, this self-efficacy total score was used to represent participants' self-efficacy level. The SEE scale is widely used in measuring self-efficacy for exercise, and it has been tested to be reliable and valid also in the case of older adults (Resnick & Jenkins, 2000). Both scale questionnaires were translated from English to Finnish and Swedish, which are the two official languages of Finland.

To analyze the participants' *changes in the stages of exercise behavior change*, the stages of change between baseline t0 and follow-up t1 were examined. More specifically, the statistical significance of the changes in the stages of change was analyzed with the McNemar-Bowker test (Bowker, 1948). The missing values were handled by excluding the responses of a particular participant if the participant had not responded to the stage of change question in both t0 and t1. To examine if self-efficacy for exercise could differentiate the program participants in terms of the stages of change, a one-way analysis of variance (ANOVA) test was performed, followed by post-hoc comparisons by using the Tukey-Kramer test (Kramer, 1956). The total self-efficacy scores were included only from those participants who had responded to all the self-efficacy statements in t0 and t1 (i.e., their self-efficacy total score was based on responses to all the nine statements). The collected data were

analyzed with the IBM SPSS Statistics 26 software, and the threshold of statistical significance was set to $p < 0.05$ for all the tests.

4 Results

In total, 320 participants responded to the stage of change question at both t0 and t1 and were, thus, eligible to be included in the sample of the present study. Descriptive statistics of these 320 participants are reported in Table 1.

Table 1: Descriptive statistics of the sample of the study (N = 320)

	n	%
Gender		
Female	197	61.6
Male	123	38.4
Other	0	0.0
Age (mean 70.0 years, SD 4.3 years)		
–64 years	25	7.9
65–69 years	112	35.2
70–74 years	140	44.0
75– years	41	12.9
N/A	2	–
Highest education		
Primary education	45	14.1
Vocational education	207	64.7
University of applied sciences	16	5.0
University	44	13.8
Other	8	2.5
Marital status		
Married	218	68.8
Common-law marriage	31	9.8
Single, divorced, or widow/er	68	21.5
N/A	3	–

4.1 Stages of change categories

The changes in the stages of change were examined through the number and proportion of participants at the five different stage categories between t0 and t1 (Table 2). More precisely, it was examined how many had moved up, moved down, or stayed at the same stage category (Table 3).

Of the participants, none were at the Precontemplation stage at t0, which could be expected considering that they had just joined a digital wellness program. One participant (0.3%) was at the Contemplation stage, 45 (14.1%) were at the Preparation stage, 57 (17.8%) were at the Action stage, and 217 (67.8%) were already at the Maintenance stage. At t1, three participants (0.9%) were at the Contemplation stage (they could, for example, have had a health issue preventing them from conducting exercise), 30 (9.4%) were at the Preparation stage, 37 (11.6%) were at the Action stage, and 250 (78.1%) were in the Maintenance stage (Table 2). Thus, the number of those at the Maintenance stage had increased from 217 to 250 (a 15.2% increase) between t0 and t1. Respectively, the number of those initially at the Contemplation, Preparation, or Action stage had decreased from 103 to 70 (a 32.0% decrease). Further, the number of those initially at either the Contemplation or the Preparation stage had decreased from 46 to 33 (a 28.3% decrease) (Table 2).

Table 2: Proportion of participants at different stages at t0 and t1 (N = 320)

	t0		t1	
Stage of change	**n**	**%**	**n**	**%**
Precontemplation	0	0.0	0	0.0
Contemplation	1	0.3	3	0.9
Preparation	45	14.1	30	9.4
Action	57	17.8	37	11.6
Maintenance	217	67.8	250	78.1

Overall, after 12 months (t1), 66 (20.6%) of the participants had moved up, 31 (9.7%) had lowered down, and 223 (69.7%) were at the same stage (Table 3). The McNemar-Bowker test suggested that the overall change in stages of change was statistically significant ($\chi^2(6) = 20.166$, $p = 0.003$).

Table 3: Changes in participants' stages between t0 and t1 (N = 320)

Stage of change	**t1** Contemplation	**t1** Preparation	**t1** Action	**t1** Maintenance
t0 Contemplation	0	1	0	0
t0 Preparation	0	14	9	22
t0 Action	1	7	15	34
t0 Maintenance	2	8	13	194

Those 217 who were at the Maintenance stage at t0, seemingly were already exercising regularly, and those 57 at the Action stage, had started their change towards it. From an effectiveness perspective, supporting those at the Action stage to continue on their path towards the Maintenance stage is of course important, but even more so is the support for those at the Precontemplation, Contemplation, and Preparation stages. Therefore, it was further examined how those participants (n = 103) at the Contemplation, Preparation, or Action stages at t0 (none were at the Precontemplation stage) were able to change their behavior, that is, how their stage at t1 differed from their stage at t0. Overall, after 12 months, 66 (64.1%) of these 103 participants had moved up, 8 (7.8%) had lowered down, and 29 (28.2%) were at the same stage. Of these 103 participants, 56 (54.4%) had moved up to the Maintenance stage.

4.2 Self-efficacy as a differentiating factor

A one-way ANOVA test was performed to examine the relationship between the stage of change and self-efficacy for exercise total score, followed by post-hoc comparisons by using the Tukey-Kramer test to determine which stages the self-efficacy measure was able to differentiate. The Shapiro-Wilk (1965) test showed that the self-efficacy total score was not normally distributed in each category being compared, more specifically, in the Maintenance stage category at t0 and t1. However, the Levene's (1960) test for homogeneity of variances showed that the variances of self-efficacy in each category being compared were equal at both t0 and t1. Thus, as both ANOVA and the Tukey-Kramer test have been found to be robust against non-normality (Driscol, 1996), there were no obstacles for their application. To be able to run the analysis, the participants at the Contemplation stage (one at t0 and three at t1) were combined with the participants at the Preparation stage. Table

4 depicts the self-efficacy means and standard deviations (SD) for different stages of change.

Table 4: Self-efficacy for exercise total score for different stages of change (N = 265)

	t0		t1	
Stage of change	**n**	**mean (SD)**	**n**	**mean (SD)**
Contemplation + Preparation	35	48.5 (17.0)	24	41.3 (17.2)
Action	51	50.1 (13.9)	32	50.8 (13.8)
Maintenance	179	59.2 (17.5)	209	63.0 (17.0)
Whole sample	265	56.0 (17.3.)	265	59.6 (18.0)

The analysis revealed that the self-efficacy total score differentiated the participants at different stages at t0 ($F(2, 262) = 9.815$, $p < 0.001$). The Tukey-Kramer post-hoc test revealed that the participants at the Maintenance stage were significantly different from those at the other stages. There was no statistically significant difference between the participants at the Contemplation + Preparation and Action stages. Similarly, at t1, the self-efficacy score differentiated the participants at different stages ($F(2, 262) = 23.148$, $p < 0.001$). The result of the Tukey-Kramer post-hoc test was also similar: participants at the Maintenance stage significantly differed from those at the other stages but there was no statistically significant difference between the participants at the Contemplation + Preparation and Action stages.

5 Discussion

The main purpose of the present study was to investigate 1) how partaking in a digital wellness program influences the stage of exercise behavior change among aged people, and to test 2) whether self-efficacy for exercise can differentiate the program participants in terms of the stages of change. The results suggest that partaking in a digital wellness program can be effective in promoting exercise behavior change among aged people. In general, this finding is in line with previous research (e.g., Stockwell et al., 2019). There was a statistically significant overall change in the participants' stages of exercise behavior change, with participants rather moving to a higher than to a lower stage during the first 12 months in the program. Of those who were at the Contemplation, Preparation, or Action stages

when joining the program, 64.1% moved to a higher stage and 54.4% to the Maintenance stage (they exercised regularly and had done so for longer than 6 months). As the Maintenance stage is the preferred stage of exercise, this observed change from the lower stages to the Maintenance stage is highly valuable from the effectiveness perspective. However, as suggested by Gorely and Gordon (2005) and to some extent by the results of the present study, relapses can take place. Thus, it is also important to continue providing support for those at the Maintenance stage.

Considering the key role of the physical activity application use in the program and the findings from previous studies (e.g., Stockwell et al., 2019), it seems plausible that these kinds of DWTs can work as BCSSs (Oinas-Kukkonen, 2013) for aged people. This likely applies both when utilized as a part of digital wellness programs and also without one, as in the present program, the participants did not have active exercise programs or counseling. However, what warrants further investigation is which application or BCSS features are particularly effective for aged people at different stages of change, as research has shown that the stage of change can have a significant role in the perceived persuasiveness of different strategies (Oyebode et al., 2021).

The results also show that self-efficacy for exercise may differentiate aged people at different stages of exercise behavior change. More precisely, those at the Maintenance stage seem to have a significantly higher self-efficacy for exercise than those at the lower stages. This is in line with previous research (e.g., Kuroda et al., 2012; Marcus et al., 1992). While the purpose of the present study was not to investigate the influences on self-efficacy for exercise, we believe that the physical activity application use could have influenced the self-efficacy levels as, for example, actions like exercise tracking and graphical review of the data can lead to performance accomplishments (Bandura, 1977).

The present study also provides some practical insights for those stakeholders working with PA and exercise promotion. First, digital wellness programs utilizing physical activity applications, or other BCSSs, seem to be potential in supporting PA and exercise behavior change. Thus, deploying such programs could be a good way to increase the PA and exercise levels of aged people. Second, as the participants at the Maintenance stage had a significantly higher self-efficacy for exercise compared to those at the lower stages, digital wellness programs should aim to increase their

participants' self-efficacy for exercise to a level matching those at the Maintenance stage. This would be highly valuable for long-term exercise adherence and, subsequently, also for healthier ageing.

6 Limitation and future research

This study has some limitations that should be acknowledged. First, due to the lack of a control group, the possible influence of extraneous variables on the results cannot be ruled out. Second, compared to the aged population in general, the sample seemed to represent a more physically active segment, as about two-thirds were at the Maintenance stage already at t0. This might have limited the size of the changes in stages of change. Future research should aim to recruit more participants also from the lower stages of change. Third, the possible influence of the COVID-19 pandemic cannot be ruled out as the restrictions, such as temporal closures of various exercise facilities and breaks in many group activities may have had a negative influence on some participants' stage of change or self-efficacy for exercise. Hence, future research could replicate the study after the pandemic and in other countries. Future research could also focus on investigating the direct relationship between self-efficacy for exercise and the stages of change in order to examine whether the changes in self-efficacy lead to changes in stages of change and how big a change is needed for that. Additionally, as longitudinal research is much called for, we encourage scholars to invest in studying how DWTs can be further utilized to support PA and exercise behavior change among aged people.

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Appendices

Appendix A. Stage of (exercise behavior) Change Instrument (Gorely & Gordon, 1995; Marcus et al., 1992)

Which of the following statements best applies to you at the moment:

- Do not currently exercise and are not seriously thinking about changing for the next 6 months. (Representing **Precontemplation**)
- Do not currently exercise but are seriously thinking of starting in the next 6 months. (Representing **Contemplation**)
- Exercise some but not regularly. (Representing **Preparation**)
- Have started to exercise regularly (a minimum of 3 sessions of at least 20 minutes per week) in the last 6 months. (Representing **Action**)
- Exercise regularly and have done so for longer than 6 months. (Representing **Maintenance**)

Appendix B. Self-efficacy for Exercise Scale statements (Resnick & Jenkins, 2000)

How confident (on a scale of 0–10) are you right now that you could exercise three times per week for 20 minutes if:

1. The weather was bothering you
2. You were bored by the program or activity
3. You felt pain when exercising
4. You had to exercise alone
5. You did not enjoy it
6. You were too busy with other activities
7. You felt tired
8. You felt stressed

You felt depressed

Exploring the Differences Between Students in IS and Other Disciplines in the Perceptions of Factors Influencing Study Program Choice: A Survey Study in Norway

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Abstract In this study, we explored the differences between students in IS and other disciplines in their perceptions of factors influencing study program choice. A quantitative research approach was employed. We used an online survey for data collection. Data was collected in a Norwegian public university in the Fall semester of 2021. The findings from this study showed that the factors that most influence students' choice of study program are career-related. The most influencing factor for students in choosing a study program was identified as job availability, followed by job security, career opportunities, and interesting work assignments. Significant differences were found between students in IS and other disciplines in the following five factors influencing study program choice: job security, opportunity to be innovative, personal skills, ease of study topics, and performance in high school subject matter courses.

Keywords: information systems, study program choice, motivations, university students, Norway.

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1 Introduction

Student recruitment and diversity have been a concern in Information Systems Departments in higher education institutions (Vainionpää, Molin-Juustila, & Arhippainen, 2022; Havelka, & Merhout, 2020), as the demand for IT-related professionals and managers has increased drastically.

Studies from various disciplines have explored the factors affecting students' decisions in choosing their study programs and careers. Influencing factors could be categorized as internal and external (Downey et al., 2011). Internal influences include attitudes, beliefs, abilities, and personality, such as one's personal image, interest and aptitude in the field, and the influence of others. External factors include job characteristics, the prestige of employment, and the degree of difficulty and workload of the major (Downey et al., 2011). Some of the factors influencing career choice are tangible such as financial rewards; others are intangible, like prestige or status (Downey et al., 2011). Skatova & Ferguson (2014) reported that people choose university degrees for four reasons: career concerns, intrinsic interest in the subject, an opportunity to help others and to find an easy way to get into higher education. Students' socioeconomic background influences their selection of major in higher education institutions (Goyette & Mullen, 2006; Johnson & Muse, 2017). Johnson & Muse (2017) reported that the lower the socioeconomic status of an individual, the more likely they are to choose more lucrative careers and careers with more favourable outlooks. Students' high school academic performance and curriculum are highly related to their choice of major (Johnson & Muse, 2017), while financial difficulties have different effects on female and male students when choosing their major (Johnson & Muse, 2017).

Vainionpää, Molin-Juustila, & Arhippainen (2022) explored why students had chosen the IT field and reported motivational factors as "interest," "IT identity," "potential of the field," "study opportunities," "people," and "desire for change". Havelka & Merhout (2020) investigate factors that influence students' decision to major in IS. They reported that for students, the first reason in choosing IS as major was new and exciting career opportunities. Chipidza, Green, & Riemenschneider (2019) reported that intrinsic motivators, such as interest and the potential for a rewarding and satisfying experience, were the strongest influencer of a students' attitude about majoring in Management Information Systems (MIS), followed by

job-related aspects of MIS, such as competitive advantage, salary, support structure, and the ease of finding a job that MIS careers offer. Li et al. (2014) grouped factors that may impact students' choice of major into three categories as career-related factors, personal interest factors, and social and referent factors.

In this current study, we investigated the differences in the perceptions of factors influencing study program choice between students in IS and other disciplines. This study aims to contribute to a deeper understanding of motivating factors in choosing IS study program in the Norwegian context, using the results of an online survey. The main research questions for this study include: What are the motivating factors in choosing study program? What are the motivational differences between students in IS and other disciplines in choosing study program? Which information sources are important in choosing a program for students? How are students' perceptions towards IS study program and profession?

2 Methodology

In this study, we used an online survey for collecting data from undergraduate students. A group of IS students and students from other disciplines at the University of Agder, Norway, was surveyed in the Fall semester of 2021. The survey questionnaire used was based on previous studies and consisted of items about the demographic characteristics of respondents, reasons for not choosing IS study program, influencing factors in choosing their study programs, information sources, and perceptions of IS. The survey questionnaire items were adapted from previous studies by Croasdell et al. (2011), Ferratt et al. (2010), Li et al. (2014), Papastergiou (2008), Snyder & Slauson (2014), Walstrom et al. (2008), Walstrom & Schambach (2012) and Zhang (2007). The questionnaire was made available in Norwegian and English. The Norwegian Centre for Research Data (NSD) approved the questionnaire before we started the collection of data. This study is a part of a larger study.

First, we sent an online questionnaire link with an e-mail to 159 IS students who enrolled in an introductory IS course. The students' registered university email addresses were used. Data was collected from IS students from September 13, 2021, to October 12, 2021. We then sent the online survey to students in other disciplines

at the same university. The survey link was emailed to registered university email addresses of 609 undergraduate students enrolled in four different courses at the Faculty of Social Sciences and School of Business and Law. Data was collected from students in other disciplines from October 12, 2021, to November 30, 2021. The survey has been administered online through SurveyXact. Participation in the survey was voluntary. IBM SPSS (version 25) software was used to analyse data.

3 Results

115 completed responses were used in this study, with 65 responses (56.5%) from students in IS (with female, n=17, 26%) and 50 responses (43.5%) from students in other disciplines (with female, n=30, 60%). 33 percent of respondents were at the age of 18-19 years, 30.4 percent of respondents were at the age of 20-21 years, 27.8 percent of respondents were at the age of 22-35 years, and the remaining (8.7%) were more than 35 years old.

Table 1 presents the mean values of the students' responses to the importance of each factor on the list in choosing their study programs and their standard deviations. Student participants in this study were asked to indicate the importance of the item listed in Table 1 for why they chose the department to study at the university with a five-point scale (1=Not important, 5=Very important). The results indicated that the most motivating factors for both IS and non-IS students in choosing their study programs was job availability, followed by job security, career opportunities and interesting work assignments. Students rated the importance of the probability of working in the field after graduation (job availability) in choosing a study program higher than personal interest in the subject matter. Career-related factors play an important role in choosing a study program at university, consistent with previous study findings (Jung et al., 2017; Snyder & Slauson, 2016; Corneliussen et al., 2021; Hodges & Corley, 2017).

The influence of high school teacher(s) was the least important motivating factor on the list in choosing a study program, followed by the counselling service at the high school, the influence of friend(s), and the influence of family member(s). The results show that the influence of friends and family members do not play an important role in choosing a study program. On average, students rated the influence of friends and family members in choosing their study programs as not important.

Table 1: Motivating factors in choosing study program (1=Not important, 5=Very important)

	Total		IS Students		Non-IS Students		
Motivating factors	**M**	**SD**	**M**	**SD**	**M**	**SD**	**p**
Job availability	4.35	0.96	4.42	1.00	4.26	0.90	0.390
Job security	4.21	0.90	4.35	0.93	4.02	0.84	0.049**
Career opportunities	4.21	0.87	4.20	0.94	4.22	0.79	0.904
Interesting work assignments	4.21	0.89	4.18	1.00	4.24	0.74	0.743
Personal interest in subject matter	4.01	1.10	4.00	1.03	4.02	1.19	0.923
Opportunity to be innovative	3.77	1.10	4.02	1.02	3.46	1.13	0.007*
Geographical location of the university	3.70	1.26	3.63	1.29	3.80	1.21	0.476
Long-term salary and benefits	3.67	1.12	3.77	1.06	3.54	1.20	0.279
Personal skills	3.62	1.11	3.29	1.20	4.04	0.83	0.000*
Choose a study where I can get the opportunity to work with people	3.49	1.25	3.31	1.30	3.72	1.14	0.078
Starting salary and benefits	3.42	1.18	3.55	1.10	3.24	1.27	0.160
Choose a study that gives the opportunity to help others	3.25	1.30	3.05	1.28	3.52	1.28	0.052
Prestige of profession	3.23	1.20	3.17	1.24	3.32	1.15	0.507
Study topics are easy for me	3.09	1.05	2.85	1.06	3.40	0.95	0.004*
Reputation of university	3.06	1.24	3.02	1.29	3.12	1.17	0.655
Reputation of degree program at university	2.97	1.17	2.83	1.23	3.16	1.06	0.134
Performance in high school subject matter courses	2.94	1.35	2.60	1.32	3.38	1.26	0.002*
Influence of family member(s)	2.25	1.14	2.08	1.14	2.48	1.11	0.059
Influence of friend(s)	2.23	1.13	2.28	1.19	2.18	1.06	0.652
The counseling service at your high school	1.81	1.12	1.78	1.12	1.84	1.11	0.793
Influence of high school teacher(s)	1.75	1.11	1.65	1.08	1.88	1.14	0.263

M = mean; SD = standard deviation; * Significant at the 0.01 level; ** Significant at the 0.05 level

T-test revealed five significant differences between students in IS and other disciplines on the following factors: job security ($p<0.05$), opportunity to be innovative ($p<0.01$), personal skills ($p<0.01$), ease of study topics ($p<0.01$), and performance in high school subject matter courses ($p<0.01$). For the two motivating factors, job security and the opportunity to be innovative, the mean values of ratings of IS students were significantly higher than that of students in other disciplines. The mean values of ratings of IS students for the importance of job availability and job security in choosing their study program were higher than the mean values of ratings of students in other disciplines. IS students rated the importance of job

security in choosing the study program significantly higher than students in other disciplines. These results show that jobs availability and job security play a much more important role in choosing a study program for IS students than for students in other disciplines. The other significant difference between students in IS and other disciplines was about the "opportunity to be innovative". IS students rated the importance of the opportunity to be innovative in choosing the study program significantly higher than other students. Information technologies today provide innumerable opportunities for innovation, and this influences students' choice of IS study program.

Ratings of students in other disciplines were significantly higher than that of IS students for three factors in choosing a study program: personal skills, ease of study topics and performance in high school subject matter courses. The highest difference between the mean values of ratings of IS and non-IS students was on "performance in high school subject matter courses". Even though it was not rated as important on average, students in other disciplines rated the importance of performance in high school subject matter courses significantly higher than students in IS.

The mean value of importance ratings for personal interest in subject matter was almost the same for students in IS and other disciplines (4.01 and 4.02). Personal interest was an important motivating factor for students in IS and other disciplines when choosing their study programs.

The results revealed that the geographic location of the university was one of the motivating factors in choosing the study program. The mean value of importance ratings for the geographic location of the university in choosing a study program was sixth on the list. It was higher than the mean values of importance ratings for "long-term salary and benefits" and "personal skills". As Kristiansand is located in the south of Norway, the University of Agder also attracts students due to its location.

Table 2 shows the importance of information sources for students in choosing their study programs on a five-point scale ranging from 1 (Not important) to 5 (Very important). Not applicable responses were coded as missing data. The university/department website was the most important information source in choosing their study programs, while the scores for other information sources were

less than three. T-test results revealed significant differences between students in IS and other disciplines in importance ratings of three information sources in choosing their study program: presentations by current students, brochures and information received at career or job fairs arranged at high school.

Table 2: Importance of information sources in choosing study program (1=Not important, 5=Very important)

	Total		IS Students		Non-IS Students		
Information source	**M**	**SD**	**M**	**SD**	**M**	**SD**	**p**
Information on university/department website	3.91	1.13	3.86	1.19	3.98	1.06	0.568
Presentations by current students	2.67	1.24	2.45	1.21	2.95	1.23	0.048**
Presentations by university staff	2.69	1.40	2.68	1.47	2.70	1.32	0.927
Media presentation of the field's reputation	2.98	1.28	2.93	1.36	3.04	1.18	0.661
Newspaper articles	1.98	1.12	1.89	1.12	2.09	1.11	0.379
Brochures	2.02	1.17	1.74	0.98	2.38	1.29	0.009*
Information and marketing via social media	2.56	1.28	2.43	1.34	2.72	1.19	0.241
Information you received at career or job fairs arranged for you at high school	2.55	1.44	2.19	1.36	3.00	1.43	0.004*
Information you received at a university Open Day (e.g. UiA)	2.20	1.44	1.94	1.38	2.55	1.47	0.043

M = mean; SD = standard deviation; * Significant at the 0.01 level; ** Significant at the 0.05 level

Students were asked to indicate their opinions towards seven statements about the IS study program and profession on a five-point scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Table 3 presents the students' perceptions towards IS study program and profession. The t-test results revealed that there were three significant differences ($p<0.01$) between students in IS and other disciplines regarding the listed statements about the IS study program and profession. As expected, IS students have more positive perceptions towards the IS study program and profession than students in other disciplines. The results show that students think IS graduates have good and well-paid jobs and that IS jobs are stable and fast-growing. The last two statements in Table 3 are about women in IS profession. An unfavourable gendered perception of the IT field can have a negative impact on women's career choices in IT/IS (Vainionpää et al., 2020). The results didn't reveal

negative gendered perceptions towards IS. In general, both IS and non-IS students disagreed with the negative statements on the list about women in the IS profession.

Table 3: Students' perceptions towards IS study program and profession (1=Strongly disagree, 5=Strongly agree)

	Total		IS Students		Non-IS Students		
Statements	**M**	**SD**	**M**	**SD**	**M**	**SD**	**p**
IS graduates have good and well-paid jobs.	3.83	0.75	3.95	0.74	3.68	0.74	0.051
IS jobs are stable and fast-growing.	4.15	0.79	4.42	0.68	3.80	0.78	0.000*
IS seems easy to study.	2.67	0.91	2.75	0.92	2.56	0.88	0.257
IS major/jobs sounded interesting and cool.	3.62	1.07	4.09	0.86	3.00	1.01	0.000*
IS studies give me the opportunity to contribute to the development of the society of the future.	4.05	0.94	4.38	0.65	3.62	1.09	0.000*
IS is more suitable for men than for women.	2.03	1.12	1.86	1.01	2.26	1.21	0.057
Men are more likely to succeed in the IS profession than women.	2.24	1.11	2.17	1.15	2.34	1.06	0.417

M = mean; SD = standard deviation; * Significant at the 0.01 level

4 Conclusion

The purpose of our study was to explore the differences in the perceptions of factors influencing study program choice between students in IS and other disciplines. We conducted an online survey among undergraduate students in a Norwegian public university.

Job availability was found to be the most motivating factor for both IS students and non-IS students when choosing their study program at a university. That was followed by job security, career opportunities and interesting work assignments. There were five significant differences identified between students in IS and other disciplines in perceptions of factors influencing study program choice: job security, opportunity to be innovative, personal skills, ease of study topics, and performance in high school subject matter courses. The importance of job security and the opportunity to be innovative in choosing a study program was significantly higher for IS students than for students in other disciplines. Students in other disciplines rated three factors significantly higher than IS students: personal skills, ease of study

topics and performance in high school subject matter courses. Results also revealed that the location of the university was an important motivating factor in selecting the study program among undergraduate student participants of this study at the University of Agder.

Although the participants of the study generally have positive views towards the IS study program and profession, students in other disciplines have less positive perceptions than IS students. In addition, it was found that the participants did not have negative gendered perceptions towards IS.

The results of the survey show that the websites of universities/departments serve as an important information source for students when choosing their study programs.

There is an obvious need to increase awareness of IS study programs among prospective students. Prospective students may not know the difference between IS and other IT-related studies like computer science. Therefore, candidate students should be given sufficient information about IS, and its difference from other IT-related study programs should be explained well.

The limitations of this study should be taken into account. First, this study used a convenience sampling technique, and the sample size was relatively small. Second, the sample consists of undergraduate students from only one Norwegian university. Third, students' university e-mail addresses were used for sending the survey's link. This may have negatively affected the survey response rate. Future studies with larger sample sizes and among high school students will help to better understand students' motivations in choosing IS.

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RETURNS MANAGEMENT PRACTICES IN SWISS ONLINE APPAREL RETAILING: A MULTIPLE CASE STUDY APPROACH

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Abstract Product returns are a critical, costly task for online retailers; yet the process of managing and avoiding returns is neither actively coordinated nor investigated. Based on a multiple case study approach, six in-depth interviews with top- and middle-level apparel industry managers were conducted to explore and describe practices of managing product returns in online apparel retailing. Our findings revealed returns management practices implemented in online apparel retailing and identified several applications to reduce the environmental footprint of product returns and improving the company's performance, based on five facets of returns management: (1) the interplay of return policy, product category, and preventive actions; (2) the application of avoidance practices; (3) the management of returns in omnichannel retail; (4) the potential of artificial intelligence to reduce return rates; and (5) the role of sustainability in consumer behaviour. To reduce product returns and enhance a company's performance, we propose to map the practices against different phases of the return journey.

Keywords: product returns, case study, online retailing, return journey, e-commerce.

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1 Introduction

Worldwide retail e-commerce sales have continuously increased over the past years and are predicted to account for one fifth of total retail sales in 2021 (eMarketer, 2021). The COVID-19 pandemic and national lockdowns accelerated the shift to online retailing (UNCTAD, 2021). In online retailing, the purchase transaction and the experience of the purchased product are typically decoupled, i.e., the consumer decides to keep, return, or exchange the product after its delivery and unpacking (Robertson, Hamilton, & Jap, 2020). Thus, returning products previously bought via digital channels is an inherent phenomenon of online retailing (Urbanke, Kranz, & Kolbe, 2015).

The growth of online retail sales and the shift from offline to online retailing increase the volume of returned products which makes product returns a growing challenge for business, society, and the environment (e.g., Frei, Jack, & Brown, 2020). As an example, every second German online shopper has returned a product previously bought online in 2020 (Statista, 2021). At an average cost of 10 euros per returned item for processing and resale (EHI Retail Institute, 2019), this has an incredible financial impact for the respective retailer and direct impact on the revenue, as more than half of the returns may not be resold at full price. Moreover, returns cause significant operational and logistical challenges and impact the carbon footprint of an online retailer (Cui, Rajagopalan, & Ward, 2020; Urbanke et al., 2015). At the same time, product returns can affect different stages of the customer journey and thus lead to also positive business impact (Robertson et al., 2020). The way how customers experience the product returns process may trigger positive word-of-mouth or build customer loyalty (Robertson et al., 2020). Thus, managing product returns is an important topic which has not been sufficiently investigated (Ahsan & Rahman, 2021; Bijmolt et al., 2021).

Specific product categories are particularly prone to product returns due to the characteristics of products and the way how the products are used and fit into the consumer's lifestyle. Apparel and shoes display the highest return rates across numerous studies (e.g., Cui et al., 2020; Statista, 2021; Urbanke et al., 2015); growth of online retail sales in this category is significant. As a result, efficiently managing and avoiding returns is paramount for online retailers in general and for apparel online retailers in particular (Bijmolt et al., 2021).

To contribute to current research on returns management and avoidance, our empirical case study explores how Swiss online apparel retailers manage the product returns process. In addition, we aim to investigate practical measures for preventing returns that take effect before the transaction and identify sustainability practices related to returns management.

2 Literature review and research propositions

The returns management process can be defined as "the supply chain management process by which activities associated with returns, reverse logistics, gatekeeping, and avoidance are managed within the firm and across key members of the supply chain" (Rogers, Lambert, Croxton, & García-Dastugue, 2002, p. 1). Rogers et al. (2002) argue that a firm's returns management capabilities can be used strategically to enhance the company's overall performance. Bower and Maxham (2012) investigated how the return policy and associated costs influence customer evaluations and subsequent post-return spending. They found that customers who are obliged to pay a fee for product returns will eventually decrease their number of repurchases, while those receiving free returns will increase their number of repurchases. These findings serve as basis for the first proposition, P1 (see Table 1).

To handle the anticipated returns, Rogers et al. (2002) recommend developing return avoidance guidelines, which means developing and selling the product in such a way that return requests are minimized. The authors argue that consistency of a product can play a critical role in return avoidance as for apparel retailers, many returns are a result of sizing issues. Therefore, Rogers et al. (2002) recommend consistently sizing the products and applying sizing guidelines uniformly across all products. See proposition P2.

Saarijärvi et al. (2017) showed that returns are the result of disconfirmation, which happens when the product does not meet the expectations the customer had when ordering the product, for instance when the material is not what the customer anticipated or when the product has one or more negative features that were not visible in the pictures. Thus, avoiding returns in a customer-friendly manner requires providing all necessary information and making sure that customers clearly understand what they are purchasing, leading to proposition P3.

The management of product returns in multi- and omni-channel retail environments is not sufficiently investigated (Ahsan & Rahman, 2021; Bijmolt et al., 2021). Multi-channel retailers may have an advantage over pure players in that they are able to offer consumers the option of returning items purchased online to a store. By utilizing this opportunity, multi-channel retailers may gain considerable benefits: for example, consumers may not only return or exchange items, but also purchase additional products (Şen, 2008). See proposition P4.

Once returns have been accepted by the retailer, they must be inspected. Blackburn et al. (2004) present two ways in which e-commerce retailers can organize their gatekeeping activities: a centralized reverse supply chain structure or a decentralized one. The major difference is where the gatekeeping takes place. A decentralized structure is more effective when it comes to handling time-sensitive returns, such as of apparel products, since the returned products can be processed (e.g., restocked/sorted) more quickly (Blackburn et al., 2004). See proposition P5.

Disposition refers to the decision about what to do with the returned product (Rogers et al., 2002). According to Blackburn et al. (2004), apparel products tend to decrease in value over the course of the season and are sold at highly discounted rates after the season ends. For this reason, the quick processing of returns is critical in the apparel industry, in order for value to be able to be recovered in a timely manner, as proposed by P6.

Petersen and Kumar (2009) find that although it is likely that a lenient product return policy will create more costs for companies in the short term, managers can use information from the behaviour of individual customers in relation to product returns as a tool for generating long-term relationship growth and maximizing each customer's profitability. The effect of tracking returns metrics is covered by proposition P7.

Product returns have considerable environmental consequences (Frei et al., 2020). Yet, research on sustainability of reverse logistics is rare (Ahsan & Rahman, 2021). Although some returns can be restocked, many are relegated to off-price channels or even end up in landfills (Frei et al., 2020). Environmental costs can directly affect the online retailer (Rogers et al., 2002). Thus, we propose the goals of the returns management include understanding of the environmental impact associated with

product returns and pursuing sustainable practices of returns processing, proposition P8. Table 1 summarizes the above derived propositions.

Table 1: Summary of research propositions

#	Proposition	Reference
P1	Offering free returns increases repurchasing.	Bower and Maxham (2012)
P2	Applying sizing measurements uniformly across all product lines prevents unnecessary returns.	Rogers et al. (2002)
P3	Providing appropriate and precise information on products prevents unnecessary returns.	Saarijärvi (2017)
P4	Offering consumers multiple options for returning their products aims at ensuring additional sales for the retailer.	Sen (2008)
P5	Decentralizing gatekeeping increases the effectiveness of returns handling for the retailer.	Blackburn et al. (2004)
P6	Quick returns processes maximize the expected market value of the returned products.	Blackburn et al. (2004)
P7	Establishing metrics for tracking customers' product return behaviour minimizes the financial impact of returns for online apparel retailers.	Petersen and Kumar (2009)
P8	The retailers are considering the environmental impact associated with product returns and pursue sustainable practices of returns processing.	Frei et al. (2020), Rogers et al. (2002)

3 Methodology

This qualitative research followed an exploratory case study approach and employed a multiple-case-study design (Yin, 2018). The chosen approach has been proved fruitful by extant research in the domain of returns management (e.g., Ahsan & Rahman, 2021; de Leeuw, Minguela-Rata, Sabet, Boter, & Sigurðardóttir, 2016; Hjort, Hellström, Karlsson, & Oghazi, 2019). The case was defined as the "retailer" and bounded by the type of activity, with only retailers involved in e-commerce (e.g., pure players, multi-channel players, or omni-channel players) being considered valid cases, industry type (i.e., retailers involved in the online retailing of apparel), and geographic area (i.e., retailers operating in the German-speaking part of Switzerland). Since generalization in a statistical sense is not a goal of this qualitative study, maximum variation sampling approach was applied (Creswell, 2007). This approach allows to document diversity and identify important shared patterns among the case

companies (Patton, 2014). Furthermore, the present study follows the theoretical replication logic by conducting six individual case studies that predict contrasting results for anticipatable reasons (Yin, 2018) and adopts a research design by following the advice of Eisenhardt (1989) in selecting cases as "polar types" given the limited number of cases studied (de Leeuw et al., 2016; Hjort et al., 2019). Case companies were selected across different sales channels, product types, and leniency of return policies. These diverse cases represent contrasting situations with respect to the setup of the returns management process, the leniency of returns policies, return activities, and returns rates. Table 2 details the case companies.

Documentation and interviews were used as sources of evidence to collect data (Yin, 2018). The retailers' websites were reviewed with the purpose of conducting a desk review of the retailers' background information (e.g., facts and figures), the terms and conditions for returns, and product detail pages to analyse which type of information on products the retailers provide online. Semi-structured interviews were conducted via Zoom or Microsoft Teams with one representative for each of the case companies. The interviews followed an interview guide, were recorded, and fully transcribed. The interviews took 59 minutes on average. All data was collected in March-April 2021 and stored in an electronic case study database. Data analysis followed an inductive approach of category development. The data analysis categories were constructed by assigning codes to pieces of data while working with the transcripts. The final names of the categories either emerged during the data analysis or were derived from incorporating the terms in the existing literature (de Leeuw et al., 2016; Rogers et al., 2002). The theoretical propositions guided the cross-case analysis (Yin, 2018).

Table 2: Overview of case companies with specified channels, product types, and return policies

#	Role	Channels	Product type	Return policy leniency[1]
MC1	Manufacturer, brand owner, retailer	Multi[2]	Day and nightwear	31 to 100 days free return guarantee
MC2	Manufacturer, brand owner, retailer	Multi	Functional sportswear	31 to 100 days free return guarantee
OC1	Retailer	Omni[3]	Premium clothing, shoes, and accessories	21 to 30 days return guarantee (free in store, customer pays the cost of returns via mail)
OC2	Manufacturer, brand owner, retailer	Omni	Athletic and casual footwear, apparel, and accessories	31 to 100 days free return guarantee
PP1	Manufacturer, brand owner, retailer	Pure player[4]	Sustainable and fair fashion	14 to 20 days return guarantee (customer pays the cost of returns)
PP2	Manufacturer, brand owner, retailer	Pure player	Sustainable clothing and accessories	14 to 20 days return guarantee (customer pays the cost of returns)

4 Results

The results of the cross-case synthesis focus on recurring patterns present across the case companies and evaluate the research propositions (see Table 1).

Proposition P1. Three of the case companies (MC1, MC2, and OC2) offer free shipping for online returns which may lead to more satisfied customers, but also to more returns. In particular, the returns rates fluctuate a lot across case companies, i.e., from as low as 5% to as high as 50% or, put differently, by a factor of ten. Yet,

[1] Return time leniency was coded in three categories: 14 to 20 days, 21 the 30 days, and 31 to 100 days.
[2] A multi-channel retailer is defined as a retailer that offers consumers two or more channels that are typically treated separately (e.g., Verhoef, Kannan, & Inman, 2015).
[3] An omni-channel retailer is defined as a retailer that technologically and organizationally integrates different channels to provide consumers with a seamless experience across the channels (Lehrer & Trenz, 2022).
[4] A pure player is defined as a retailer that only operates an online channel, but no physical bricks-and-mortar stores (e.g., Xing & Grant, 2006).

if the returns rate of OC1, the only multi-brand retailer in our study, is eliminated, we find that, on average, the single-brand retailers that charge for returns (e.g., PP1 and PP2) have a lower returns rate than retailers that offer free returns (e.g., MC1, MC2, OC2). The interview with MC2 revealed that free returns are offered to create a secure environment for a customer so that if the customer is hesitant about a purchase, she still makes an order. Having lenient return policies helps a lot with that. Yet, whether offering free returns increases repurchasing could not be confirmed.

Proposition P2. All case companies indicate that avoiding returns of apparel products is impossible because consumers are uncertain about the size and fit of products bought online. However, by applying sizing measurements uniformly across all product lines online apparel retailers may reduce the returns rate. For example, the returns rate for existing and loyal customers of one case company is around 15% only as these customers know the company's products, know how the products fit, and what exact size to order. These customers mainly purchase clothing items on the retailer's website. In contrast, those customers ordering products from the same company on marketplaces have an average returns rate of almost three times as high.

Proposition P3. All case companies emphasized that they are continuously trying to improve their websites with the aim of minimizing returns. To provide an overview of the various online avoidance practices, we checked the product details pages for all of the case companies and determined the particular return-avoidance practices. We chose a black T-shirt for women in size S as the base for the analysis, since this is a basic product offered for purchase by all the retailers. The most frequently mentioned and implemented practices used by the online apparel retailers to avoid product returns are presented in Table 3.

Table 3: Overview of returns avoidance practices

Type of avoidance practice	MC1	MC2	OC1	OC2	PP1	PP2
Product name	X	X	X	X	X	X
Product description	X	X	X	X		X
Additional product information	X	X	X	X		X
Product use information	X	X	X	X		X
Product material characteristics	X	X	X	X	X	X
Flat photo of the product		X	X	X	X	X

Zoom image on hover	X	X	X	X	X	X
Photo of the product on model	X	X	X	X	X	X
Additional photos on a model	X	X	X	X		X
Specification of model's height			X		X	
Specification of the size the model is wearing			X		X	
Photo of the product in other colours	X	X	X	X	X	
Size guide	X	X		X	X	X
Size and fit tool (e.g., Fit Finder or EYEFITU)			X	X		
Product rating	X	X			X	
Product reviews	X	X			X	X
Information about return policy	X	X	X	X	X	X

Proposition P4. MC1 and MC2 do not offer their clients an option to return items purchased online to a store. In case of MC1, it is currently not possible due to the company's organizational setup. In case of MC2, the reason for this is that all of the online orders are sent out from the central warehouse in Germany, and all returns from Switzerland must be sent back to Germany for the inspection. OC1 offers its customers free returns in store with the aim to increase store traffic. Interestingly, only 20% of online returns are brought back to OC1 stores. The rest of online returns is being sent back by mail, in which case the customers must bear the cost of postal service. In case of OC2, it is also possible to return clothing items purchased online to a physical store. The OC2 interview suggests that mainly loyal customers make the effort of going to a store to return an item and possibly make another purchase.

Proposition P5. It was found that a centralized returns system is utilized by all the case companies to standardize operations processes and minimize labour costs related to returns. To collect returned products and transport them to the central warehouse, the case companies rely on the large parcel carriers active in Switzerland. To handle the returns at the central warehouses, all of the case companies have established a separate "returns department."

Proposition P6. All case companies mentioned that since returns are collected in the central warehouses, the returns are processed all at once, as quickly as possible to maximize the expected market value of the returned products. The inspection and

sorting of the product returns are still manual processes. On average, the case companies process the returns within one or two days upon arrival at the central warehouse and make these products available for order online immediately after.

Proposition P7. All case companies have a framework in place for tracking return rates. The interview with OC1 revealed that the returns rate is tracked per brand and per category per brand and compared to the previous period. In addition to quantitative analysis of the returns rate, MC2 conducts a more qualitative analysis and identifies the most frequently returned products with the aim to uncover potential patterns related to product quality, inconsistent sizing, and unsatisfactory fit. The main rationale behind tracking the returns rate and the returns reasons is to identify the products that are out of the ordinary, check them, and then either change the product description online or change the product itself.

Proposition P8. Certain sustainable practices undertaken by the retailers aimed at reducing the environmental footprint caused by product returns were identified. First, all case companies are working on a solution to reduce the number of physical documents which are sent to the customers along with the merchandise. During the interviews with the case companies, it was revealed that on average, a retailer sends three sheets of paper for each order (e.g., invoice, delivery note, pre-printed return label). In case the returns rate is 30%, then 70% of customers do not return their orders and consequently, throw away the paper sheets. For a multi-channel retailer, 70% may constitute approximately 500,000 boxes or 1,500,000 sheets of wasted paper. Second, most of the case companies do not chemically clean returned products which have signs of wear. Instead, they are sold at outlet sales. There is also an indication that the retailers are considering reducing packaging. Two of the case companies are already building steps toward the more sustainable return practice and offer their customers delivery with reusable packaging, which can be returned and reused up to 20 times.

5 Conclusion

This study contributes to the growing body of knowledge on the management and avoidance of product returns in online apparel retailing in five different ways. First, we shed light on the interplay of return policy, product category, and avoidance practices. Second, we uncover potential for new practical measures to reduce the

return rate. Third, we explore the management of returns in multi- and omni-channel retail environments. Fourth, we identify potential for the use of automation, algorithms, and artificial intelligence to reduce return rates. And fifth, the identified sustainable practices point to a framework for a more systematic analysis thereof.

Our results suggest that free returns are positively correlated with returns rates. A major reason to offer lenient return policies is to reduce the consumer's hesitance to make an order, which can be closely linked to the inherent specific features of the product category. Size and fit are the major reasons for returns in online apparel retailing. We found that both specific information related to the depicted models and size-and-fit tools seem relatively sparse avoidance measures, which points at three avenues for further research in this regard: (1) adoption and acceptance of size-and-fit tools at retailer and customer side; (2) how do size-and-fit tools as new touchpoint make or break the customer experience and customer journey; and (3) impact of size-and-fit tools on return rate and customer satisfaction and loyalty.

At strategic level, managers need to weight the benefits and costs of lenient return policies. With lenient policies, return rates are most likely to increase. Effective preventive measures can decrease the probability of a return. Thus, managers need to well align effective preventive measures with return policies. Lenient policies can result in the desired positive effect while effective avoidance practices ensure that customers are less likely to make use of the policy. Further research may uncover how this interplay can be designed most effectively.

Multi- and omni-channel retail environments create various paths for returning products previously bought online. Extant research suggests the returns in stores can trigger new sales and early phases of new customer journeys. Our study reveals that the implementation of in-store returns can be hindered by "multi-country operations" (returns sent to country other than that of customer residence and physical store) and organizational setup. We also found evidence that in-store returns are actively pursued by designing the return policies (esp. cost structure) favourably to in-store returns. Future research should investigate what specifically hinders the implementation of in-store returns. This is especially vital in the apparel industry since in-store returns combined with decentralized gatekeeping can speed up the overall returns process and increase the chance of selling returned products at full price.

Our study further reveals that retailers utilize two approaches to track returns behaviour for improving the financial impact of returns: a) start with product, category, or brand, and then check for return reasons; b) start with highest return rates and identify respective returns reasons. Both approaches are pursued rather manually. Future research should explore how automation, algorithms, and AI can be utilised to, e.g., speed up the process, discover new patterns of return reasons, or to automate measures for preventing returns.

Finally, we identified several practices pursued to reduce the environmental footprint of product returns. To unleash the full potential of making returns more sustainable, we propose to map the practices against different phases of the return journey, i.e., before the product is returned, when the product is returned, and after the product has been returned. Future research should systematically analyse the practices' economic and environmental effects.

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Effective IT Use Among Residential Caregivers: The Role of Autonomy, Competence and Relatedness

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Abstract Technological innovation in the healthcare sector is increasing, but integration of information technology (IT) in the care process is difficult. Healthcare workers are important agents in this IT integration. The purpose of this study is to explore factors that feed motivation to use IT. Self-determination theory (SDT) is applied to study how motivational factors impact effective IT use among frontline caregivers in residential care settings. As the team is very important to these caregivers, the team is our unit of analysis. In an embedded single case study design, interviews were conducted with all nine members of a team effectively using IT. All three basic psychological needs from SDT - autonomy, competence and relatedness - were found to have impact on effective IT use, though autonomy was primarily experienced at team level. Conversely, the effective use of an IT collaboration tool influences relatedness.

Keywords: self determination theory, effective IT use, residential care, theory of effective use, motivation.

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1 Introduction

In many countries the pressure on the health sector is large and increasing. The COVID-19 pandemic has increased this pressure even further. Effective use of digital resources can provide a solution for the increasing pressure and many digital innovations have been introduced in the care and health sector. To achieve the required impact, however, digital innovations must be adopted and used by healthcare professionals (van Houwelingen et al., 2016; Venkatesh et al., 2003). It is therefore important to understand what motivates healthcare professionals to use IT effectively. As a recent survey of twenty long-term care professionals in the Netherlands shows, "knowledge, motivation, self-image and attitude were at least as important for the adoption of digital tools as purely developing digital skills" (van Mierlo, 2020). Motivation is thus seen as a key concept, which refers to mechanisms that stimulate and direct behaviour (Kleinginna & Kleinginna, 1981). In this study we investigate the relation between motivation and the effective use of IT innovations by caregivers in residential care teams. Residential care constitutes a large proportion of care providers. Of the 1.4 million employees in the Dutch care sector, for example, more than 20% work in nursing and care homes. And this does not include residential care for people with disabilities, mental health issues or youth.

A well-known theory of motivation is the self-determination theory (SDT), which has been extensively empirically tested (Ryan & Deci, 2000). SDT considers the quality of a person's motivation more important than the extent to which someone is motivated. The theory distinguishes various types of motivation and contends that the more autonomous types of motivation are the ones that produce lasting behaviour (Gagné & Deci, 2005). This focus on motivation leading to lasting behaviour, makes SDT suitable for the study of effective IT use by health care providers, in terms of continued use of IT in work processes and the continuous active contribution to innovation.

This study aims to contribute to the growing body of knowledge on motivational aspects of IT use, integrating insights from psychology, as expressed in the self-determination theory (Deci & Ryan, 2000) into the information systems (IS) discipline.

2 Theoretical Background

As many studies of effective IT use are based on one of the various technology adoption theories, this section starts with a brief discussion of these. When studying motivation in particular the self-determination theory is very relevant, which recognizes the importance of psychological need satisfaction. The section concludes with a brief discussion of what constitutes effective IT use.

2.1 Technology adoption theories

Various technology adoption models have been developed over the years. Well-known examples of models and theories include Theory of Planned Behavior (Ajzen, 1991), Technology Acceptance Model (Davis, 1989; Venkatesh & Davis, 2000), Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), Innovation Diffusion Theory (Rogers, 2003) and Information Systems Continuance Theory (Bhattacherjee, 2001). Many acceptance models consider intention to be an important predictor of usage, with the amount of intention being determined by the degree to which certain antecedents are present. This approach, however, has also been criticized as the evidence for these models is ambiguous (Li, 2010).

2.2 Self-Determination Theory

Self-determination theory (SDT) is developed and refined by Deci and Ryan over the last four decades, and this theory of motivation is based on much empirical research (Deci & Ryan, 2000). In the last decade and a half, SDT has also received attention in research in the IS domain (Lee, Lee & Hwang, 2015; Nguyen & Hess, 2020; Roca & Gagné, 2008; Chiu, 2022). SDT focuses on the quality of motivation and argues that to induce lasting behaviour requires more autonomous types of motivation (Gagné & Deci, 2005).

SDT recognizes three psychological needs, which are innate, universal and essential for growth and (inter)personal functioning (Ryan, 1995), namely autonomy, competence and relatedness. These basic psychological needs energize human behaviour and must be continually fulfilled for a person to function optimally and experience well-being (Deci & Ryan, 2000).

Satisfaction of basic psychological needs fosters autonomous motivation which in turn has a positive impact on work performance (Baard, Deci & Ryan, 2004; Gagné & Deci, 2005). In SDT (Ryan & Deci, 2000), autonomy is defined as experiencing freedom of choice and feeling free to initiate one's own behaviour (De Charms, 1968). Competence is defined as the feeling of efficacy, the feeling of being able to succeed when interacting with the environment (White, 1959). Finally, relatedness refers to the need to "belong" and being focused on forming and maintaining strong and stable ties with others (Baumeister & Leary, 1995).

Several studies investigate the basic psychological needs in IT use in a work setting. These papers report an influence of all three basic psychological needs (Andersen, 2016; Rezvani et al., 2017; Roca & Gagné, 2008). However, there is not yet a unified picture about which and how basic psychological needs influence (the motivation for) IT use. Conclusions on the extent to which autonomy, competence and relatedness have an influence differ among the studies. Studies are mainly quantitative and focus on the extent to which needs are met. Less is known about how and by whom or what needs are supported when it comes to IT use in the workplace, let alone in the specific work setting of residential care.

2.3 Basic psychological needs in IS research

Several quantitative studies integrate basic psychological needs into the technology acceptance models and theories from IS research mentioned in section 2.1 (Hsu, Tsai, Kuo, Ya-Hui & Lien, 2016; Assadi & Hassanein, 2017; Roca & Gagné 2008; Bhuasiri, Zo, Lee & Ciganek, 2016; Lee et al., 2015; Rezvani, Khosravi & Dong, 2017; Sørebø, Halvari, Gulli & Kristiansen, 2009). However, a difficulty in integrating SDT constructs into existing IS adoption models is that these theories are based on fundamentally different basic principles. SDT is not based on the degree of motivation, as the IS models are, but on the quality of the motivation which is arranged on a continuum from less to more self-determined (Ryan & Connell, 1989), with the more autonomous, self-determined types of motivation being better predictors of optimal functioning (Gagné & Deci, 2005; Ryan, Kuhl & Deci, 1997). Moreover, SDT links motivation directly to behaviour, not to the intention to behave. This difference in fundamental principles is not addressed in these studies.

2.4 Effective IT use

For an information system to be successful, it must be accepted and used in an organization (Venkatesh, Morris, Davis & Davis, 2003). However, when a caregiver uses more IT, it does not mean that they are providing better care. Therefore, when it comes to IT use, it is important to consider not only the degree of IT use, but also the manner and quality of this use (Sykes & Venkatesh, 2017). The Theory of effective use (Burton-Jones & Grange, 2013) can inform IS research on the quality of IT use. In this theory effective use is defined as "using a system in a way that helps attain the goals for using the system" (Burton-Jones & Grange, 2013, p.633). Goals are attained by performing actions that are afforded by the IT system. The connection between actions and goals can be complex, however, requiring a network of actions with intermediate outcomes (Burton-Jones & Volkoff, 2017; Raymond et al., 2018). According to Burton-Jones & Grange (2013) user activities can be broken down into accessing the system, obtaining faithful information from the system, and acting on this information (Burton-Jones & Grange, 2013). This seems to hold for an organizational context, though in other contexts, such as social media, other types of activities may occur (Eden et al., 2020).

Effective use by the individual does not happen in isolation from the general work context but can be analyzed from the perspective of the goals for which it is used, and can involve multiple actors at multiple levels (Burton-Jones & Grange, 2013; Burton-Jones & Volkoff, 2017). Within residential care organizations, the care team is one of the most important levels from which work is performed (Gosling, Westbrook & Braithwaite, 2003). Residential care is provided by a team of employees who work in a varying shift pattern, to jointly support the assigned client population 24/7. This type of care requires multi-functional employees who collaborate in highly interdependent way with each other. Therefore, for effective use of IT innovations in daily processes, it is important not only to consider the individual in isolation, but to study them in the context of the team.

3 Research Method

Based on the important role of the team in residential care, we chose the team as unit of analysis. An embedded single case study design was used to investigate the relation between the need for autonomy, competence and relatedness and the

effective use of IT. The research was conducted within one residential care team from a Dutch organization for care of people with intellectual disabilities. This organization implemented Microsoft 365, a digital information and collaboration platform, in the period from late 2018 to early 2019. Since this platform covers a large number of applications and services and as explained above effective use depends on the system and its goals, this study focuses on the effective use of the Teams application, as the core application for team collaboration within this platform.

Within this organization, a team was selected as a case, based on theoretical sampling (Eisenhardt, 1989). For this purpose, a residential care team was sought that was representative of the behaviour under study and thus scored high on effective IT use in the post-implementation phase. To objectively select a team, criteria were defined in a focus group. The focus group was composed of a heterogeneous group of five professionals whose work involves the implementation and/or use of the technological innovation among providers of residential care. Theoretical insights from Theory of effective use were used as input for the focus group meeting (Burton-Jones & Grange, 2013; Burton-Jones & Volkoff, 2017). Six aspects of effective IT use were formulated: active use of Teams, everyone participates, communication by Teams, direct response, collaborating on documents, and perceived own effectiveness. Based on the first three of these criteria a shortlist of effective teams was made, by measuring usage data. The champions of the shortlist teams were briefly interviewed by phone to measure the other three criteria. The team managers of the top two teams were then approached for participation. The number one team manager agreed to participate.

The selected team consisted of nine employees. Their work experience in healthcare was gained within the team. Two-thirds of the team members had worked on this team for six or more years. Two team members were very open to new IT and were intrinsically motivated to see what can be done with it. A number of members experienced new technology more as a necessity, which cannot be avoided at work, although they also saw its usefulness.

Each of the nine employees of the selected team participated in a semi-structured individual interview. These interviews took place via online video meetings during the period from March to April 2021. Depth was obtained by asking open-ended

questions, following the interviewee verbally with their own wording in order to enrich the answers without leading in a direction (DiCocco-Bloom & Creabree, 2006), and by asking follow-up questions. The questions pointed in a general direction to motivations, underlying needs, and antecedents. Examples are: "What caused you to start using this IT? ", "Who or what was needed to do this?", "Who or what supports you in this activity?", "What is holding you back?". Follow-through questioning, respect and attention was used to facilitate interviewees in formulating (previously perhaps unconscious) motivations. In addition, a number of set questions were asked about demographic characteristics such as gender, age, and work experience.

Interviews were transcribed according to the verbatim principle. The analysis phase of the study was conducted according to the thematic analysis method of Braun & Clarke (2006). An initial inductive round of coding was conducted, using the in vivo coding method (Miles, Huberman & Saldaña, 2020). The codes from this first round were next categorized into themes of stimulating and hindering factors. In a third round a deductive approach was used, in which the three concepts of autonomy, competence and relatedness served as analytical dimensions.

4 Interview analysis and interpretation

Associations to each of the three basic psychological needs were found in all interviews. The following sections discuss how the three basic psychological needs come into play in participants' use of IT.

4.1 Competence

From the interviews it appeared that competence in an application such as Teams is not limited to competence in system access and system functionalities but is also required when dealing with and acting on content. Difficulties were experienced in absorbing and retrieving all information. Sometimes messages were missed. As reasons participants mentioned the amount of information (#2, #6, #8), one's own attention span (#1), system deficiencies (#9) or unknown (#1). When information in Teams is the basis for acting (correctly), missing that information impedes the ability to succeed in tasks, which leads to a feeling of frustration. This is not just about the individuals need for competence; in team tasks, missing information by an

individual affects the success of the entire team: "I just notice that I sometimes miss entire messages, strangely enough. And I'm not the only one, I recently learned… A pretty important one, of things that had to be arranged… if in this manner you miss things and miss a deadline because of that, then that's pretty annoying, either for yourself, or for your colleagues." (#1).

When the own competence appeared to be inadequate, help was freely sought from immediate colleagues: "We work in a team where that is fairly easy, you know. So, then you ask… then they watch what you do, ah, you have to do that so and so. They are also quite practical in all those things." (#5). Taking time to increase one's own competence is indicated as a stimulating factor by the vast majority of participants. However, when it comes to increasing skills, time is expressed in diminutive terms: "a small lesson" (#1), "little piece of explanation" (#1), "small, brief training" (#3), "just an hour or two" (#5), "this particular point ... go over it with each other for a moment" (#7). Asking for help outside the direct circle of colleagues or one's own network does not happen often. It takes longer in the perception of some and external help from a helpdesk is not available in the evenings.

There appeared to be one task for which no team member had a good understanding of how the application works. For this task, the team-wide sense of competence was clearly low. The need for outside instruction on this point is mentioned by the majority of participants. So even in a team selected for a high degree of effectiveness in use compared to other teams within the same organization, there are still opportunities for growth.

The basic psychological need of competence is nourished from one's own knowledge, skills and experience, a high degree of ease of use of the system and readily available peer support. Competence, the feeling of being able to succeed, could be nurtured even more by external training on a select number of functionalities. Making time for this is seen as an important factor. Within the case study, all individual team members experienced a sense of competence for daily task performance. Microsoft Teams as an IT innovation has become part of the daily routine. The application is perceived as easy to use.

4.2 Autonomy

The reason for the team to start using Teams was an obligation from the organization. Initially, little individual freedom of choice was experienced. The subsequent use of online meetings was also prompted by an external actor: the lockdown declared by the Dutch government to reduce COVID-19 infections meant that meetings with the team were no longer possible without the use of online meeting tools. The response was characterized by the acceptance of the situation and acceptance of what is coming to the team, both in individual and team attitudes: "If this is asked of me and someone or [the organization] wants me to do it, yes, then go let's do that." (#2); "I think we're pretty docile in what's being offered and we don't hold on to the old, but go with it, do what is offered." (#8). However, an obligation from the organization is "no guarantee of success", explained one of the participants, "something intrinsic will have to happen" (#7). An important element here was the (quick) recognition of usefulness, which was experienced by the whole team in efficiency increase through fast, transparent communication and clear and findable information: "Back then it was kind of a must. And now it's like, yeah, it might be quite useful." (#4); "See, I will. But you have to see the benefits quickly." (#8).

Some participants described the choice to use Teams or certain functionalities as a joint decision in a team meeting (#4, #6). Freedom of choice was experienced by members in the way Teams can be used and configured by the team. Participants experienced the possibility of improvements in various ways. While some had a more internal locus of control and were seeking for more effective use in increasing their own skills, others put their hopes in improvements in the system.

The basic psychological need for autonomy is fed by the decision-making space that the team experienced in how to use it. Within the existing room for maneuver, decisions are made collectively and there is a sense of freedom of choice at the individual and team level. By starting to use the system, usefulness was quickly experienced, which contributed to the perception of wanting to use the tool oneself. Little autonomy was experienced in the implementation phase. However, the obligatory nature of the start does not seem to frustrate the need for autonomy, but is met with an attitude of acceptance. The obligation from outside was followed by a movement from within the team itself.

4.3 Relatedness

By communicating via Teams, team members became aware of what was going on at the site and among colleagues, asked each other for an opinion or help and received response. This provided a sense of connection with each other: "I call it connection. Yes, you want to feel connected,… you know what is going on. And with each other. And it's also, yeah, just a piece of, yeah how do you say, social control with each other. Also towards your colleagues, is someone okay, or are things not going good with someone. Yes, sometimes I don't work with a certain colleague for two weeks, then it's very nice that you can see oh, what has she been working on and that kind of thing." (#3). Conversely, relatedness was frustrated when communication is missed and team collaboration is less optimal as a result.

The need for relatedness when using IT is fueled by mutual support, which is a matter of course. Team members help each other "with all the love" (#3), "of course" (#5) you ask each other for help, "it's just a safe team to do that" (#8). Qualities and skills of others were noticed and used.

When the participants looked back at the start of the innovation, the feeling was that it was done together, in connection with each other. A few participants also mentioned a motive to go along with the group: "When this is offered to the team and you start working with it, yes, you just go along with it."(#2); "You are not the only one to say: I will be the only one to work with this while the others do not, or the other way around." (#4). The driving force behind this experiment was one team member, who had already been assigned to handle IT issues within the team. With a team of nine, the presence of one such person appears to be sufficient, provided this person can get others on board. The initiator of the experiment outlined a number of conditions that were important to bring the team to use IT, such as marking and creating a safe practice environment and coaching.

The need for relatedness was satisfied by nearby peer support in daily task performance and the mutual sharing of user experiences. The fact that the team members experience the team as a safe, trusted environment was helpful here. The need to belong to the team encouraged participation in the joint use of Teams. The start was experienced as a joint effort, spurred on by one individual, supported by the collective.

Effective use of a collaboration application like Teams itself, also contributes to the satisfaction of the need of relatedness. Through effective communication and collaboration via Teams, ties with teammates were maintained and strengthened.

5 Discussion and Conclusion

The results show that not only the individual needs are important. In team tasks, need satisfaction of other team members also has a relationship with one's own effective IT use as well as with performance at the team level. Basic psychological needs are mainly satisfied by direct colleagues. Satisfaction of competence and solidarity with one's own team members seem to go hand in hand. When it comes to satisfying the need for autonomy, it is mainly aspects at the team level that are considered important. The need for a collective decision space and the value attached to initiatives from within the team itself point to the collective rather than the individual. Satisfaction of individual need for autonomy seems to play a lesser role. Also, remarkably little is said about the manager. Within the investigated case there does not seem to be a significant role for the direct manager when it comes to effective IT use.

The relationship between basic psychological needs and effective IT use is not a one-way street. In the case of relatedness, this becomes clear from the data. Perhaps this reciprocity in relationship is also present with autonomy and competence. The interviews focused on what is needed for effective use, however, and what results from that use was not explicitly explored.

Based on the results, the following preliminary conclusions can be drawn:

- Autonomy is experienced at the team level and is satisfied by having decision space within the team and facilitating a movement from within the team.
- Competence is satisfied by investing time in increasing one's own knowledge, skills and experience, by having a system with a high degree of ease of use and by having direct support from others.
- Relatedness is satisfied by a perceived shared commitment, mutual discussion of user experience, a safe team climate and close peer support.

- Effective IT use itself contributes to the satisfaction of basic psychological needs. Effective use of a communication and collaboration application feeds relatedness.

This empirical study aimed to contribute to the growing body of knowledge on motivational aspects of IT use, integrating insights from psychology into the IS research domain. The perspective of self-determination theory shows to be useful for clarifying the prerequisites for continued effective IT use. This qualitative case study indicates that among Dutch residential caregivers, the satisfaction of all three basic psychological needs is involved in effective IT use.

Whereas in earlier quantitative technology acceptance studies competence, relatedness and autonomy are used as antecedents of concepts, such as effort expectancy and perceived usefulness, feeding in turn intention, we found that, the other way round, ease of use feeds competence. It may be worthwhile to consider reversing the relationship in technology acceptance studies, positioning the abovementioned concepts as antecedents to competence, relatedness and autonomy, feeding in turn IT use.

As with any study, there are limitations. First, the method used, a single case study, has drawbacks. Caution should be exercised in generalizing; a generalization to the population cannot be made. The case was purposively selected for representativeness in terms of effective IT use and does not reflect the population. This limits the study to analytical generalization (Yin, 2018). Moreover, results may be related to idiosyncrasies that occur only in this team. As a result, analytical conclusions are not as strong as they would be in a multiple case study.

Second, although the interviewer attempted to create a safe setting and approach participants openly and empathically, there may be an effect of conscious or unconscious social desirability in the response, which is inherent in personal interaction. Social desirability bias and the fact that the case represents most effective IT use, may have resulted in negative aspects such as frustration being less apparent than in reality.

There are some avenues for further research. The results attest to a team in which needs are met primarily within the team. Willingness to help and team safety are high, and intensive communication takes place. Because of the data collection method of individual interviews and thematic analysis based on a theory from psychology, little attention has been paid to the role of sociological aspects, such as group dynamics and team functioning. Sociological theories could inform further research into factors at the team level of residential care. Gosling, Westbrook & Braithwaite (2003) already showed that better team collaboration results in more effective use of IT. Also results from the current study point towards a possible influence of team level factors on effective IT use.

Also, the reciprocity of the relationship between basic psychological needs and effective IT use could be tested.

A final suggestion for follow-up research is to build theory around the integration of SDT concepts and existing technology acceptance models, addressing differences in fundamental principles. This would benefit further research into the qualitative aspects of motivation to use IT.

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METHOD FOR MORE SUCCESSFUL USAGE OF AIRBNB BY HOSTS AND GUESTS IN DEVELOPING COUNTRIES

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Abstract In this paper we aim to propose a method for more successful usage of Airbnb platform by the hosts and guests in North Macedonia. To achieve this, we have performed qualitative research and interviewed twenty individuals. The collected data was analyzed through grounded theorizing. Based on the analysis we identified that the dimensions under which the hosts have most control and through which can impact the value perception of the guests is the bargaining power they have. To increase the bargaining power, we have identified steps that the hosts should follow. These proposals are empirically based and practically useful.

Keywords: sharing economy, AirBnB, usage, challenges, developing countries.



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1 Introduction

The sharing economy enables usage of goods and services without owning them. The sharing economy could be defined as "a closed socio-economic system facilitated by digital platforms which match peer-to-peer service demand and offer based on the rules and culture of the platform actors" (Miguel et al., 2022). However, sometimes these rules and participation practices are not clear and might become barriers for participation in the sharing economy. This could be a strong challenge for usage of these platforms by hosts in developing countries. As more and more international travel is organized through sharing economy platforms, for example Airbnb, it is important to explore how the hosts can improve their success on the sharing economy platforms.

According to Zervas and colleagues, the combination of supply flexibility and technological advancement by simplifying suppliers' market entry and maintaining low transaction costs is taken as a major factor in the rapid growth and development of these platforms (Zervas et al., 2017). In fact, as Munger points out, these are goods and services for which there was previously no economic justification to mediate in sharing transactions because the costs associated with establishing them were high (Munger, 2018). In other words, the exponential development of technology as a whole and the Internet, with Tunca highlighting network effects as a crucial component (Tunca, 2019), play an important role in easy user access, rapid dissemination and global use. This provides opportunities for hosts in the developing countries to actively participate in the sharing economy. However, participation in the sharing economy also brings challenges and problems that are associated with risks for users in terms of their security, legal regulations, etc. that affect the intensity of use and user experience associated with sharing economy platforms. Identifying how these challenges can be overcome is important in stimulating international tourism in developing countries.

The aim of this paper is mapping the challenges and problems faced by users (hosts and guests) of the Airbnb platform in North Macedonia and propose a method for more successful application of sharing economy business models in North Macedonia by the hosts. Success is defined by taking the whole user experience into account when establishing the success rate KPIs. Starting from how the offer is communicated to the actual deliverables in terms of accuracy of what is promised.

The end goal is an increase in the booking rates, as well as increase in the number of users/frequency of platform usage. To achieve this first, we discuss the sharing economy problems and challenges. Then we present the interview method and usage of grounded theorizing. After that we present the findings. This is followed by a presentation of the developed method that could be transferred to other developing countries. Finally, we provide the conclusions.

2 Sharing economy, challenges, and problems

The beginnings of the sharing economy are closely linked to the emergence of platform-based businesses in a variety of industries that mediate sharing and exchange of goods and services. One of the first widely known examples of exchange platforms we can detect is eBay (eBay, 2020). As eBay breaks through the market, the sharing economy becomes a direction with the emergence of the widely known and accessible platforms Couchsurfing, Airbnb, Uber, Lyft, etc. in the first decade of the 21st century.

Although the sharing economy includes the element of sharing, it is strictly different from the generally accepted phenomenon of sharing, because "sharing is a phenomenon as old as humanity, while collaborative consumption and the" sharing economy" are phenomena pervasive in the Internet age" (Belk, 2014, p.1595). According to Zervas et al. the combination of supply flexibility and technological advancement by simplifying suppliers' market entry and maintaining low transaction costs is taken as a major factor in the rapid growth and development of these platforms (Zervas et al., 2017). In other words, the exponential development of technology as a whole and the Internet, with Tunca highlighting network effects as a crucial component (Tunca, 2019), play an important role in easy user access, rapid dissemination, and global use. Considering that this is a relatively new direction in the economy that leaves its mark in various industries, most authors in determining this phenomenon focus on different aspects. Codagnone and Martens emphasize that there is no generally accepted definition and that the offered definitions are more extensive (representation through examples, from a practical point of view explain key elements with a realistic approach) than connotative (precise definition and categorization of the term) (Codagnone and Martens, 2016). Therefore, instead of presenting specific definitions, in order to understand the term Sundararajan identified five characteristics (market-defined, efficient use of excess capacity, peer

to-peer based networks, removing barriers between private and professional, as well as approximating the meaning of full-time work and contract work) as a starting point for accurately distinguishing a basic system of sharing economics (Sundararajan, 2016), while also including claims by other authors. On the other hand, Botsman and Rogers identify four principles of the sharing economy: critical mass, resting capacity, and belief in the common and trust between strangers (Botsman and Rogers, 2010).

Different authors take different views on the dilemma of whether sharing economy platforms are based solely on access to goods and services or involve the transfer of ownership of them. Hamari et al. include access through the possession or sharing of goods and services and access through the transfer of possession (which means donation, exchange or purchase) as categories of the sharing economy that can overlap (Hamari et al., 2015). In contrast to this classification, the European Commission emphasizes that "transactions in a collaborative economy generally do not involve a change of ownership" (DocsRoom - European Commission, 2016, p.3), although it is also stated that "it may involve some change in intellectual property" (DocsRoom - European Commission, 2016, p.3). There are also classifications in the literature where when determining the nature of activities they are limited to access without exchange of ownership (Bardhi and Eckhardt, 2012; Schlagwein et al., 2020). Interestingly, authors like Botsman and Rogers do not stop at including or excluding different types of sharing from the concept itself, but through different criteria such as the supply of platforms, the stage of maturity of the organization and the reasons for its existence differentiate the types of systems of sharing economy, such as: product service system, redistributive markets and collaborative lifestyle (Botsman and Rogers, 2010).

2.1 Sharing economy in the Republic of North Macedonia

According to Trajanov and his associates, in Republic of North Macedonia sharing is seen as a social norm led by a long tradition between acquaintances (friends, relatives, neighbors) and is widespread in everyday communication. Although sharing is a routine habit between individuals, the classic form of sharing economy is in its early stages in R.N. Macedonia. Despite the barriers that these authors identify as a lack of trust and a sense of cooperation in order to develop a sharing economy, the use of services of this type has a positive growth trend. They also

predict that these services will play an important role in our country's economy in the near future mainly through a better understanding of the people for the benefits they can receive at the individual level (Trajanov et al., 2018).

From the spectrum of platforms of the sharing economy represented on a global level, the Airbnb platform is widely used in R.N. Macedonia (Trajanov et al., 2018). An atypical form of sharing initiative in our market is intercity sharing organized between individuals through Facebook (Santa and Ciunova Shuleska, 2019).

Based on the research done, the number of papers on the sharing economy topic in R.N Macedonia are limited. While based on the statements in the text above we can conclude that the use of sharing economy platforms in R.N. Macedonia is in its beginning stage. The barriers mentioned while using these kinds of platforms states the need for further, deeper research on this topic. But, it is also clear that there is a potential for wider use of these kinds of platforms in our country based on the fact that there are sharing activities happening without any platform based mediation. That said, this paper is covering the types of difficulties the users have as well as provides a method for more efficient use of the sharing economy platforms throughout the method created. By taking the usage of only one platform in consideration we were able to bring more valuable, concrete findings and come up with specific deliverables to create the method in the focus of this paper which in the future could be modified to adapt different sharing economy platforms as well.

2.2 Challenges and problems of sharing economy

In this section we present the identified weaknesses on a global scale and how they will serve as a base for detecting problems that create barriers to the use of sharing economy platforms in the Republic of North Macedonia. Based on the analysis we have identified the following weakness: fluctuation or lack of regulation, providing benefits only to middle class individuals, lack of trust in digital platforms, and lack of trust in the other side users led by information asymmetry.

Fluctuation or lack of regulation. Innovative business solutions bring with them regulatory challenges that need to be addressed through consistent regulation of new forms of supply in order for them to bring economic benefits, benefits for the environment and for the participants themselves. However, as identified by von

Briel and Dolnicar through the years there is a fluctuation in the regulations (von Briel and Dolnicar, 2020). For example, with time the accommodation sharing regulation is relaxed. However, there is fluctuation thus sometimes certain cities have more relaxed and then more restricted regulation (as is the case of Vienna) (von Briel and Dolnicar, 2020).

Providing benefits only to middle class individuals. Schor (2017) explains that most of the service providers on these platforms are highly educated individuals with the goal of generating additional income by performing occasional manual work. As a result, the sharing platforms introduce additional competition to labor workers employed in the hospitality industry.

Lack of trust in digital platforms. One of the biggest barriers for users to use this type of platform according to research conducted in the EU is the ambiguity of who is responsible for the occurrence of a problem (PublicOpinion - European Commission, 2018, 2016). To mitigate this problem the platforms introduce rules based on algorithms and analysis of the available data. However, the access to personal data is one of the problems of these platforms that affect individuals' trust in digital platforms and the Internet as a whole (Calcaterra and Kaal, 2020). To certain extent this is mitigated by dividing the personal data in public and private and introduction of security measures (Scassa, 2018).

Lack of trust in the other side users led by information asymmetry. These platforms are based on information asymmetry (Sundararajan, 2016). The problem with asymmetric information is the difference in information held by both parties in a particular exchange or sharing in the sharing economy, especially because of the nature of the goods (partially used) and the customized services provided by different individuals (Connelly et al., 2010). Boulding and Kirmani (1993) explain that sellers of high-quality products and services communicate the attributes of products and services in order to raise their price, while sellers of low quality send inaccurate information or conceal information about the quality of products and services to compete with the competition. Botsman refers to these signals as trust signals or indicators through which the other party decides to engage in a particular interaction (Botsman, 2017). The signals (or information offered online) have a significant function on the platforms of the sharing economy, this can be seen through the research of Xie and Mao (2017) by taking a specific example of a

platform, Airbnb. User behavior in previous transactions and ratings of the offered listings on the platform in the form of reputation and rating is taken as one of the factors for transmitting information to the other party as a signal of confidentiality (Xie and Mao, 2017) that helps the market to function by mitigating the risk of asymmetry in available information.

Using these problems as a starting base we want to explore what are the problems the participants from North Macedonia face during their activities on AirBnb as a accomodation sharing platform. To achieve this we performed empirical research with the following method.

3 Methods and data

To answer the research questions, we performed qualitative research. The purpose of qualitative research is to understand the human behavior within the real world which is primarily complex (Price et al., 2015). Interviews are taken as the primary method of gathering information for qualitative research (Qu and Dumay, 2011). As a result, interviews were performed with twenty individuals (ten hosts and ten guests) from Skopje and Ohrid. When selecting respondents from the host group, the focus is on individuals renting apartments, not hotels or hostels. The questions (adapted for both groups) focused on covering the experiences and knowledge of both categories of users and they are open type (even if a question of yes / no type arises, they were followed by why so that the respondent has the opportunity to further elaborate and to express themselves in their own terminology). Due to the Covid-19 pandemic interviews were conducted online, via Zoom (online communication tool) with subsequent transcripts of answers. The performed interviews vary in an average time frame of 54 minutes for the respondents - guests and 80 minutes - interviews with the hosts of accommodation on this platform. For a small number of respondents, who refused to communicate via Zoom call, the interview was done by using a written questionnaire. By noticing shortcomings in the data after the revision of the transcripts (small number), the respondents were additionally contacted to supplement, further explain their claims.

The interview questions were divided into 6 groups of questions: introductory questions, usage process, strengths, weaknesses, suggestions for improvement and possibility for addition. Categorization of the phases and processes as well as

strengths and weaknesses, including recommendations for improvement, the plan was used to develop a method for more successful hosts participation on Airbnb platform.

The collected data was analyzed through the grounded theory approach. Grounded theory falls into the category of empirical, qualitative research because it supports systematic data analysis and continuous interaction between the data collection and analysis process (Urquhart et al., 2010). After conducting the interviews, a classification of the original codes was made, through which the data was categorized into broader topics (preliminary categories) followed by second-instance coding (dimension development). Based on developed codes and identifying the relations between them we moved towards identification of key concepts. By following this process, we made sure that the link between the empirical data and the identification of key concepts is done without omitting information (Parks et al., 2017).

4 Findings

4.1 Guest

Using the 3-level coding method, an analysis of the data from the interviews with groups of respondents, guests was implemented and 3 main characteristics related to the use of the Airbnb platform from the category of guest users were summarized. The three characteristics are valuable perception, technology and consistency of supply. In addition, the logic behind the created elements and what they have will be elaborated.

Value perception. This dimension reflects the value of the listings that guests see when choosing accommodation. Guests rely on information in the form of signals provided by the listing itself. For the guest to get a sense of the value of the accommodation they are observing, it is generally based on five components: validation, visual perception, information relevance, communication, and personalization.

Consistency of offer. While the first dimension refers more to the offer that the listing provides for the guest, the second dimension includes the offer on the platform itself which is consistent with the promise of the brand, which it offers continuously so that the guest decides to first consider Airbnb's choice before

another alternative option. This dimension is defined by five categories including mediation, quality, interaction, price sensitivity and supply diversity.

Technology. Given the fact that platforms of this type require the incorporation of technologically advanced, innovative solutions for their effective functioning, it was not surprising to point out the features of the platform and suggestions for improvement in that direction. The main categories of this dimension are intuition, functionality, pre-selection, accessibility, and flexible approach.

4.2 Hosts

For the hosts, through the process of grounded theorizing, four dimensions that play a crucial role in sharing services through Airbnb were identified. Those dimensions are bargaining power, platform mediation, technology and regulation.

Bargaining power. Bargaining power as a dimension is primarily composed of categories that allow hosts to display the value of the listing, including the full scope of their offer. By summarizing and analyzing the statements of the respondents, five categories of data were derived: interaction, relevant information, price competitiveness, visual perception, and current changes.

Platform mediation. By classifying the possibilities that the platform provides for easier and more efficient use of it for hosts, this dimension encompasses the components are focused on easiness and efficiency. The categorization includes protection, support, rivalry, validation, and access.

Technology. The smart technological solutions offered can be singled out as an important dimension when using the platform. The components of this dimension are intuition, functionality, assistance, and availability that the platform establishes or needs to improve.

Regulations. The dimension of regulations refers to state laws, rules and restrictions established by the Republic of North Macedonia. The remarks and suggestions of the hosts move in the direction of structuring appropriate, official regulations for this type of rental and simplifying the necessary processes related to this type of rental accommodation through their full online implementation, without exceptions.

Determining the basic dimensions and components for both sides of the Airbnb platform provide a base for elaboration of specific challenges faced by both sides of the users of the sharing economy platforms through the prism of use of the Airbnb platform. This provides the information that the proposed method for improving hosts participation on Airbnb will take into account the needs of the guests.

5 Proposed method

To propose a method through which the challenges can be overcome by the hosts and guests we compare the identified dimensions through the claims they make and compare them in the form of positive experiences, perceived weaknesses, and suggestions for improvement. The result is that we have identified that three dimensions are the same for both types of users: technology, platform mediation and consistency of efforts. These dimensions act as intermediaries between the hosts' bargaining power and guests' value perception. They are also provided by Airbnb and cannot be changed by the hosts or the guests. However, when compared the hosts' bargaining power and guests' value perception, we identified that they are different description for the same situations, as presented in Table 1:

Table 1: Hosts' bargaining power vs guests' value perception table

Hosts	**Guests**
Bargaining power	Value perception
Bargaining power as a dimension is primarily composed of categories that allow hosts to display the value of the listing, including the full scope of their offer.	Value perception is the value of the listings that guests see when choosing accommodation. Guests rely on information in the form of signals provided by the listing itself.
Dimensions matching	
interaction	communication
relevant information	information relevance
visual perception	visual perception
current changes	validation
	personalization
price competitiveness	

When we combined this match with the analysis of the problems and proposals for improvement of the usage of Airbnb we were able to identify the following relations between both dimensions and present them in Figure 1.

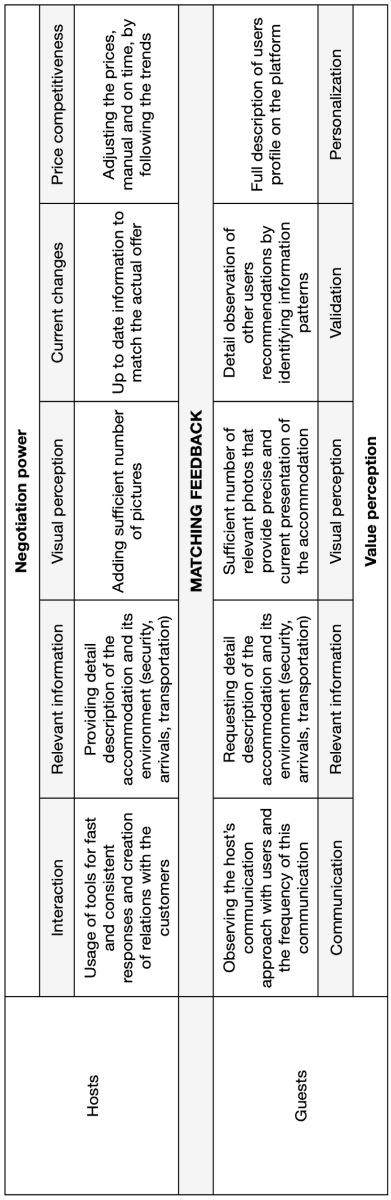


Figure 1: Matching dimensions with activities

Based on the above, we theorize that the process of improving the participation of the hosts in AirBnB from North Macedonia is impacted by increasing their bargaining power. By increasing their bargaining power, the hosts will increase the value perception of the users and as a result could attract more hosts. We present this relation in Figure 2.

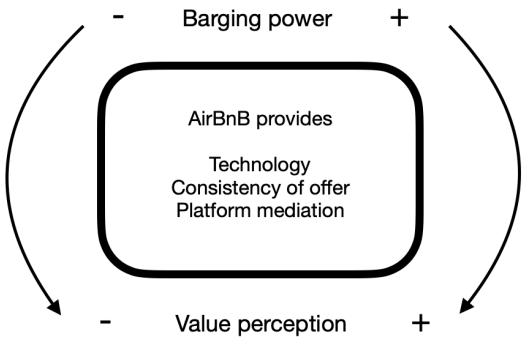


Figure 2: Relation between barging power and value perception

Based on the results, in order hosts to increase their success on Airbnb they should:

- Improve their interaction by using tools for fast and consistent responses and creation of relations with the customers
- Provide relevant information by providing detail description of the accommodation and its environment (security, arrivals, transportation)
- Improve the visual perception by adding enough pictures
- Keep the information up to date to match the actual offer and
- Adjusting the prices, manual and on time, by following the trends on the platform

6 Implications

The aim of this paper, as mentioned above, is by mapping the challenges and problems faced by hosts and guests in using the Airbnb platform in North Macedonia to propose a method for more successful usage of Airbnb platform by the hosts.

The established research helped us to determine the dimensions that have the greatest impact on the success of the use of platforms from the sharing economy (bargaining power and value perception), as well as dimensions that play an accompanying role (technology, platform mediation and consistency of the offer). A direct proportional relationship is seen between the two most influential dimensions, with the increase of the bargaining power of the hosts, the value offered for the guests increases and vice versa. Therefore, as these two dimensions essentially represent the way and the level of user involvement, the practical part of the method is focused on going into more detail on the factors that have an impact and how they can be properly applied.

By precisely defining the basic dimensions and factors that have the greatest impact on the use of the Airbnb platform in our country, we have successfully laid the foundation for what users should devote the most impact to and how it should be implemented in a wider range of platforms in the sharing economy in R.N Macedonia.

On theoretical, aspect our model provides additional insight how the factors that impact quests behavior on sharing platforms is matched with the factors that impact host behavior. We demonstrated that these factors are complementary and demonstrated a positive feedback.

7 Conclusion

In this paper we aim to propose a method for more successful usage of Airbnb platform by the hosts in North Macedonia. To achieve this, we have performed qualitative research and interviewed twenty individuals. The collected data was analyzed through grounded theorizing. Based on the analysis we identified that the dimensions under which the hosts have most control and through which can impact the value perception of the guests is the bargaining power they have. To increase the bargaining power, we have identified activities that the hosts can make. These proposals are empirically based and practically useful. However, we also faced some limitations in this study. First, the number of participants could be higher, but due to the Covid-19 we faced practical limitations in identifying and interviewing individuals. Second, we focused our research on North Macedonia and there is a

need for additional studies to evaluate the transferability of these suggestions to another context. These limitations open avenues for future research.

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Designing Urban Participation Platforms – Model for Goal-oriented Classification of Participation Mechanisms

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Abstract Citizens are increasingly shaping their city self-determined. To do so, they use digital platforms to start projects, gain awareness or raise funds. These and other participation mechanisms enable citizens to participate in manifold ways. With the help of the tree ring model introduced in our contribution, we present a tool that is intended to support practitioners in evaluating and developing their platforms. The model was designed based on the analysis of 22 existing platforms as well as a literature review and evaluated in qualitative interviews. The result is a tree ring model that shows a new understanding of participation apart from hierarchical structures. The citizens' role classification and the possible mechanisms that can offer practitioners effective implications for the design of participation platforms.

Keywords: participation, bottom-up urbanism, smart citizens, participation platform, self-governance.

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1 Introduction

Citizens are increasingly shaping their city self-determined and independently. This urban trend aims to make urban space more livable (Finn, 2014) and is summarized under the term bottom-up urbanism (Kickert & Arefi, 2019). The focus lies on the citizens and their needs. In this type of participation, self-development, the responsibility and the decision-making power for urban design is transferred from the city government level to the citizens themselves (Abel, Miether, Plötzky, & Robra-Bissantz, 2021). The resulting freedom of design and decision-making (e.g., over the distribution of available resources) takes place in accordance with the needs of the citizens, but detached from the level of government (Rauws, 2016).

Bottom-up initiatives, such as community gardens, are initiated, planned and organized by citizens. The implementation of projects takes place with little financial means, independent of city administrative structures and with the help of digital participation platforms (Abel et al., 2021). The aim of the initiatives is to shape the city according to the ideas of its residents (Finn, 2014). Citizens participating on the platforms act as consumers and producers of content at the same time (Manetti, Bellucci, & Bagnoli, 2017).

For the classification and evaluation of participation, the Ladder of Participation by Arnstein is the *"benchmark"* (Collins & Ison, 2009). But Arnstein's hierarchical model understands participation as a *"categorical"* concept of the distribution of powers (Arnstein, 1969). Today's understanding has changed and participation is no longer understood as a hierarchical concept of maximum authority. Rather, the focus has shifted to the consideration of the citizens and their reasons for participation (Tritter & McCallum, 2006). Which leads to a more open and broader understanding of participation with diverse levels and roles.

In addition to our previously outlined understanding, the way we participate is also changing. If participation is supported by information and communication technology, it is called eParticipation (Sæbø, Rose, & Skiftenes Flak, 2008). Even if eParticipation in general is an area that has already been extensively researched (Medaglia, 2012; Sæbø et al., 2008; Susha & Grönlund, 2012), digital participation platforms are still a largely unexplored subject of research. Initial research results can

be found in the field of political platforms (Irani et al., 2012) and in the context of urban design (Falco & Kleinhans, 2018; Gün, Demir, & Pak, 2019).
It remains to question the application of these research results, the generalizability of the findings and the transfer to individual sub-areas of participation and to demand an adapted model (Panopoulou, Tambouris, & Tarabanis, 2014). Otherwise, there is a risk that tools of participation will be inappropriately applied to the context (Collins & Ison, 2009).

The hierarchical model of Senbel & Church (2011) is often used to classify participation platforms (Falco & Kleinhans, 2018; Gün et al., 2019). This evaluates a platform as a whole and only at the highest level of participation that is offered. This approach neglects the participation mechanisms for lower levels within a platform and thus the different roles of the users. But there is not a linear conceptualization of participation with a clear delimitation of the levels (Tritter & McCallum, 2006).

In the cities of the future, there is growing interest in the term Smart City. In addition to the technological perspective, the discussion also focuses on social interaction and participation (Gil-Garcia, Gasco-Hernandez, & Pardo, 2020; Nam & Pardo, 2011). Despite this increased interest, there is a lack of a thorough understanding and practical application (Collins & Ison, 2009).

Practical models show different understandings of roles at the institutional level and from the citizens' perspective (Straßburger & Rieger, 2014). However, the models lack the transfer of the understanding of roles on platforms and which functions can be implemented in practice. In the application of participation platforms in the context of bottom-up urbanism, we see different goals and thus also the participation mechanisms offered differ (Abel et al., 2021).

The questions about framework, roles and mechanisms form the starting point of this work, which pursues the goal of making a scientifically sound and practical contribution in the field of participation platforms in bottom-up urbanism. As a result, we aim at answer the following research question:

How can the mechanisms of participation platforms in the area of bottom-up urbanism be classified in the spectrum of participation?

Specifically, the participation mechanisms used by platforms are to be categorized, classified and visually demarcated in a participation model in order to fill the current gap of systematization of functionalities and mechanisms in platform design (Falco & Kleinhans, 2018; Tambouris, Liotas, Kaliviotis, & Tarabanis, 2007) and to make them accessible as a practical tool.

2 Theoretical Background

The question of how we will live in cities in the future is currently being discussed in the context of smart cities. There, *"smart citizens"* are increasingly being envisioned as central actors who network, use new technologies and actively shape their environment themselves (de Waal & Dignum, 2017). The focus lies on participation (Gil-Garcia et al., 2020) and the change to a participatory city administration (Albino, Berardi, & Dangelico, 2015). Participation is understood as taking part or being involved and addresses the insight and influence of the citizens involved in planning and decision-making processes (Collins & Ison, 2009). This development overtakes Arnstein's hierarchical understanding of participation (Arnstein, 1969). Rather, the focus should be on the problem and thus, the type of participation and collaboration as well as the mechanisms to be used with it (Collins & Ison, 2009).

According to Wilcoxes' (1994) model, the competition of the levels is shifted into a collaborative idea of participation. The levels of participation differ in their use depending on expectations and interests. With its framework of different dimensions, it creates an equal connection between levels of participation, the course of the project and the stakeholders. For Wilcox, the levels of participation are a means to the end of meeting expectations and covering the various interests that change during a project and that involve stakeholders in their changing roles.

This actor-centered perspective also extends the model of Hurlbert & Gupta (2015) by adding the problem to be solved to the participation levels. Participation processes are also understood as a learning field, around the problem and the solutions, which goes hand in hand with the further development of the citizens.

The Senbel & Church (2011) model represents a concrete and practical approach for participation in urban design processes and is often used to classify digital participation platforms. Even though there is a growing body of knowledge on technology in participatory processes (Desouza & Bhagwatwar, 2014; Ertiö & Bhagwatwar, 2017; Falco & Kleinhans, 2018; Gün et al., 2019) there has been no specific research regarding the highest level of participation on platforms. These levels of participation are understood as levels with increasing empowerment and thus shifting Arnstein's (1969) understanding that power of citizen only exists at the highest level.

Empowerment through participation is a central theme of participation, which can act as a differentiation of levels. Involvement is the degree of temporal commitment and activities (Wolf-Wendel, Ward, & Kinzie, 2009). This perspective can be used for the platform operator as well as the design of the participation mechanisms. Similarly, engagement is used as a qualitative degree of involvement from the perspective of the participants, i.e., how they feel involved (Wolf-Wendel et al., 2009). The engagement thus represents a perspective of the citizens on the participation opportunities applied by them.

In the participation pyramid by Straßburger & Rieger (2014), the growing scope for citizens to be creative is emphasized in line with their increasing degree of participation and the perspective of institutions and organizations is taken. This reflects the changed understanding of the role of the citizen towards becoming a co-creator, who helps develop the cities or shapes the design independently (Foth, 2017; Simonofski, Asensio, & Wautelet, 2019).

The differentiation of levels raises the question where *"real"* participation, being a subset of participation in general, begins. It implies the following aspects:

(1) The joint and consensual decision-making through mutual communication in contrast to sovereign action. (2) The participation in decisions in public space (3) by parties, who do not routinely make such decisions. (4) Participation implies a transfer of power to the groups of people involved, which in turn, (5) embody people with legitimate concerns in a sufficiently representative manner so that they distinguish themselves from simple lobbying work. (Newig, 2011)

3 Methodology & Study Design

In order to answer the leading research question in this article, the authors based upon the research framework of Design Science Research (DSR) along the five-phase cycle of the General Methodology of DSR according to Vaishnavi & Kuechler (2015). The design-oriented approach and the interlinking of theory and practice motivated the selection of the DSR for the practice-oriented research project (Frauchiger, 2017).

First, the authors conducted a literature search using the central concepts of *"participation"*, *"DIY urbanism"*, *"social media"*, *"bottom-up urbanism"*, *"eParticipation"* and *"self-governance"* in various databases (including Google Scholar, Science Direct, SpringerLink) and tracked down further specialist articles with the help of the *"snowball method"* in order to work out the theoretical grounding for the research project from existing models and theories. Second, as part of a preliminary study on the population and definition of digital participation platforms from the area of bottom-up urbanism, we identified 22 out of 143 platforms which provide their users the highest level of participation. These allow the creation of projects by citizens and empower the citizens themselves to implement and realize these projects mostly in a do-it-yourself manner (Abel et al., 2021); this basis is used for the present study. The object of investigation on the platforms were the participation mechanisms that provide active involvement in the citizens' projects by enabling functions on the platforms. In the sense of triangulation, the authors recorded participation mechanisms that were identified independently of one another in a matrix structure (see Table 1) and sorted them according to functions (inductive category formation). Differences and similarities were discussed in the research team in order to confirm or adapt the categories formed. Third, based on the literature and platform analysis, a first model prototype was created to classify and systematize participation mechanisms. In a joint design process the authors incorporated the theory and research as a "creative leap" (Kuechler & Vaishnavi, 2012) into a tangible artifact. Forth, for reflection with the aim of evaluating the designed model prototype, a qualitative survey in the form of semi-structured interviews was then carried out with four participation platform operators. This step took place within the DSR evaluation in order to assess the contribution to problem solving of the artifact (Hevner, 2007). We chose stratified sampling to *"capture major variations"* from the original preliminary study with the outcome of different priorities funding, discussion and implementation (Patton, 2014).

The one-hour interviews were recorded as audio files and then transcribed using the amberscript software. This was followed by a systematic systemic evaluation of the interviews according to Mayring & Fenzl (2019). In the pursuit of this, the research team assigned statements by the respondents to the categories of participation mechanisms identified through an empirical study on the platforms in order to evaluate their relevance from a practical point of view. In addition, the interviewer then presented the visualization of the model to each platform operator surveyed (see Chapter 4) and asked for an interpretation of the model shown, followed by a discussion and reflection of the individual components. As a result, criticism of individual aspects could be discussed to gradually improve the model.

4 Results

The empirical study on the platforms led to the partial result of the identification of ten participation mechanisms on platforms, which can be assigned to four identified goals of participation (*transparency, co-determination, decision making, self-governance*). Table 1 provides an overview of the mechanisms found on each of the 22 participation platforms examined.

Transparency as a goal includes the *like* and *follow* functions as a measure of the reputation and trustworthiness of the liked post, with the follow mechanism acting as a substitute or supplement to the consenting like because of its additional networking function. For the *information* mechanism, the platform acts as a medium for collecting and providing information on the project. (Kietzmann, Hermkens, McCarthy, & Silvestre, 2011)

Table 1: Investigated platforms and mechanisms used

mechanism	sum of mechanisms	information	like	follow	comment	share	survey	crowdfunding	(offline)involvement	team entry	project start
goals		transparency			co-determination			decision making		self-governance	
frequency		100%	45%	9%	64%	5%	68%	68%	68%	7%	82%
Sandkasten	8	●	●		●		●	●	●	●	●
WeChange	8	●		●	●	●	●		●	●	●
Space Hive	8	●	●	●	●		●	●	●		●
Raumpioniere	8	●	●		●		●	●	●	●	●
Openberlin	7	●	●		●		●		●	●	●
die Urbanisten	7	●	●		●		●	●	●		●
Place 2 help	7	●	●		●		●	●	●		●
Les Co-citoyens	7	●	●		●		●	●	●		●
Ecocrowd	7	●	●		●		●	●		●	●
Voorjebuurt	6	●	●		●		●	●			●
Hannovermachen	6	●	●				●	●	●		●
ioby	5	●			●			●	●		●
Nordstarter (Startnext)	5	●			●		●	●			●
Rabryka Welt	5	●					●		●	●	●
Move for Hunger	5	●					●	●	●	●	
Gut für Nürnberg	5	●			●		●	●			●
Yooweedoo	4	●					●	●			●
PLATZprojekt	4	●					●		●		●
Casa Schützenplatz	4	●			●		●		●		

Patronicity	4	●		●	●	●
Urban Green Newcastle	2	●			●	
Sager der Samler	1	●				

Source: own elaboration; presentation based on Gün et al. (2019)

At the level of the goal of *co-determination*, *crowdfunding* for networking and *financing a project* on the part of a large number of (external) project supporters and *(offline) involvement* are classified (Gerber & Hui, 2013; Schwienbacher & Larralde, 2010). The latter mechanism enables project participation even for a limited period of time in order to achieve intermediate goals.

The *self-governance of the citizens* shows the goal with the highest citizen involvement and includes the functions of *joining a team* and *starting an own project*. A conscious *team entry* as a member (Oser, Ullrich, & Biedermann, 2000) within the framework of bottom-up urbanism is when the participating citizen consciously decides to support a project for a longer period of time and supports through various forms of assistance such as knowledge, time and physical training contributes to the project. The mechanism *project start* offers the possibility not only to consume content but also creating new content in the form of a project before its implementation. In this way, users can submit their own projects, thus laying the foundation for further collaborative and creative cooperation (Bruns, 2007).

The results of the platform analysis illustrate that not all of the platforms examined contain all of the defined mechanisms. Furthermore, the mechanisms are implemented in an extremely diverse way, which results in a strong heterogeneity of the respective platforms.

The *project start* mechanism occupies a special position. Platform users who start a project initiate the participation of other platform users. Project initiators share their vision of the future and thus invite participation to build it together.

To provide a tangible outcome of our research we developed the tree ring model (see Figure 1) as a result of the DSR process with several iteration loops. Our aim is to offer practitioners assistance in selecting the appropriate participation mechanisms for the respective situation.

In the synthesis, the following aspects from the theoretical background are integrated into our model. (1) A framework in a non-hierarchical form, participation subsets in connection with the degree of involvement & engagement. The framework area is based on Collins & Ison (2009) and Wilcox [28] elliptically designed framework, which visualizes information, consultation and participation as subsets of social learning. This contour reminiscent of tree rings as a metaphor for personal development of participants is where the model takes its name from. (2) The functional role of the citizens involved, were derived from the Split Ladder of Participation by Hurlbert & Gupta (2015) and the changing relationship between citizens and the city administration (Foth, 2017). In consideration of bottom-up urbanism, various roles are therefore derived from Foth (2017) and Simonofski et al. (2019) (observer, expert, central designer, collaboration partner) distinguished from citizens. (3) A systematization of the participation mechanisms specified for digital platforms. Thereby, the goals reflect the intention of the participation design, while the sub-ordinate mechanisms embody the reason to reach this goal.

They are increasing gradually according to the degree of involvement & engagement which is based on Straßburger & Riegers (2014) participation pyramid.

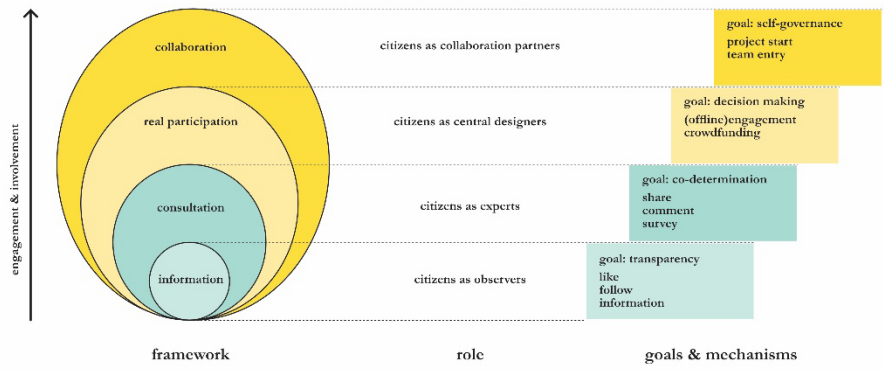


Figure 1: **Tree Ring Model**
Source: own elaboration

If there is a situation in which a platform operator would like to promote citizen involvement, the appropriate tree ring of participation can be identified depending on the situation. The framework should serve to classify and delimit participation characteristics in the model. The ellipses are to be understood as integrative subsets.

This means that information and consultation represent a subset of *"real participation"*, but that *"real participation"* is differentiated from the other two sub-areas downwards – also in terms of color. If the role and the sub-area fit together, the designer moves horizontally to the right-hand side and finds the goal of the sub-area and the associated participation mechanisms there.

In the context of the classification of the mechanisms in their respective ellipses, the information mechanism occupies a special position within all mechanisms, which is mainly due to its generality and passivity of the user. It is elementary for participation platforms in order to guarantee transparency and was found on every participation platform.

The like, follow, comment, share and survey mechanisms are assigned to the consultation. These mechanisms have in common with the information mechanism that they achieve a visible effect, be it on the platform itself or be it on other social media platforms. The platform user becomes active by means of these mechanisms, insofar as he produces or distributes content himself, although sometimes only in the form of a reaction (e.g., like, share).

With the mechanisms crowdfunding, (offline) involvement and team entry, participation in the narrower sense is mentioned for the first time. The assignment of the mechanisms is based on the requirements for *"real participation"*. In the meaning of a subset of participation, *"real participation"* is mainly defined by its cooperative character, which calls for a joint exchange of resources between the actors involved. In this context, cooperation requires the right to co-determination of all those involved, which in turn presupposes a handover of power by those usually in power. In the case of crowdfunding, this resource is funds. In the case of (offline) involvement and team joining, the shared resources correspond, depending on the specific role, to e.g., drive, knowledge or skills. The citizen thus actively contributes to the design of the project and at least indirectly determines the implementation of the project.

5 Evaluation

The tree ring model offers a formalization of participation mechanisms of digital participation platforms. By restricting the variety of platforms and their mechanisms, a classification based on literature and reflected by expert interviews could be carried out along the level of participation. The model primarily serves platform operators and founders in the (further) development of their platform. Participation mechanisms should be selected based on the anticipated role of the citizen. This application was confirmed in expert interviews with the platform operators of the four digital participation platforms Sandkasten, Raumpioniere, WeChange and Rabryka. The practitioners suggested the color design for a better understanding of the demarcation between participation and real participation or the sharpening of the term *involvement and engagement* (instead of prior involvement). The classification of the participation mechanisms within the associated goals found its way into the model through the reflection of the platform operators. In addition, as part of the evaluation, some mechanisms were shifted to other levels, as this turned out to appear more reasonable, especially in practical application. For example, the mechanism for *"team entry"* changed its original position from the *"real participation"* level to the *"collaboration"* level. The main reason for this was the structural differentiation between helpers and team members by the practitioners.

At the same time, the unresolved main point of criticism arises from the individual experiences of the platform operators that the model greatly generalizes and simplifies the actual individuality of participation platforms, although the participation mechanisms on the respective platforms have different weightings and values – depending on the context, as well as the implementation and interaction of the mechanisms. The authors also noticed the diversity of the platforms examined, both in terms of their structure and in terms of the mechanisms and divergent intentions selected. It should therefore be noted critically that, depending on the design of a platform and the interpretation of the mechanisms, practitioners might gain different insights. As a result, the tree ring model should be understood as a framework for orientation and users should always be encouraged to make individual adjustments (e.g., specializing the term *"citizen"*, adding roles or mechanisms).

As an orientation framework, the simple structure of the model was understood by all four interviewees and highlighted positively. In particular, the *"tree rings"* (in the left model area) are highlighted as a successful alternative, as opposed to a hierarchical model. In addition, the platform operator of Raumpioniere confirmed that the model would be helpful for the intended target groups, platform operators and functionaries. The feedback validates the model design with regard to its intended user group.

6 Conclusion and Outlook

With the trend towards bottom-up urbanism, a large number of participation platforms have emerged that offer their users a wide range of participation options. This diversity is primarily due to the respective offer and the design of the participation mechanisms of a platform. The attempt to formalize these mechanisms makes a contribution with the presented tree ring model to systematize the mechanisms of participation platforms and to classify them in the spectrum of participation in the area of bottom-up urbanism. In addition, the term *"real participation"* was separated from the hierarchically subordinate functions of information and consultation and upwards from collaboration.

The achievement of the research goals and the benefits of the tree-ring model of participation developed iteratively from theory and practice was confirmed in expert interviews, but at the same time provides the starting point for necessary further research in this area to shape an understanding of arising forms of participation. We see our research value as another piece of the puzzle to understand and design bottom-up participation of the 21st century. The tree-ring model offers a zoomed out perspective to shape the understanding of our roles in a bottom-up society to build the future cities we want to live in. And if we zoom in on the existing platforms the concrete model helps to make this discourse tangible.

However, there are some limitations, since both the participation platforms analyzed and the platform operators surveyed come mainly from Germany and the northern hemisphere although participation platforms are represented worldwide. As a result, an application or further development for international participation platforms has to be researched and possible cultural peculiarities have to be taken into account for

the classification of the mechanisms. The mechanisms themselves are also more fundamentally defined and the user perspective, such as motivation, was not part of this work, but might be a valuable extension.

In conclusion, we demonstrated that a participation platform primarily defines its individuality. A large number of configurations can be summarized under the ten identified mechanisms. One example is the different design of the *Like* mechanism on the Sandkasten and Raumpioniere platforms. Some mechanisms fit into different sub-areas and, depending on the platform design, can be assigned to *"real participation"* or lower levels of involvement & engagement. Depending on the founding phase or platform intention, this can lead to the goal and effect of the mechanisms contradicting the results presented here. Future research projects could investigate to what extent an adaptation of the model to different platform concepts is reasonable and valuable.

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Data Science in Government Agencies: The Challenge of Deployment and Operation

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Abstract Despite the numerous business benefits of data science, the number of data science models in production is limited. Data science model deployment presents many challenges and many organisations have little model deployment knowledge. This research studied five model deployments in a Dutch government organisation. The study revealed that as a result of model deployment a data science subprocess is added into the target business process, the model itself can be adapted, model maintenance is incorporated in the model development process and a feedback loop is established between the target business process and the model development process. These model deployment effects and the related deployment challenges are different in strategic and operational target business processes. Based on these findings, guidelines are formulated which can form a basis for future principles how to successfully deploy data science models. Organisations can use these guidelines as suggestions to solve their own model deployment challenges.

Keywords: data Science model, data science deployment, informatio value chain, government case study.

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1 Introducton

Expectations of the benefits of data science models are high. For instance, data science models can enable business model changes (e.g., Chen, Schütz, Kazman, & Matthes, 2017). Propelled by increased accessible infrastructure and computing power, and the acquisition of more volumes of data accumulating into big data, big data analytics is thought to be one of the most valuable strategic business sources in the coming years (McAfee & Brynjolfsson, 2012).

Literature reports on exemplary successful case studies of Facebook (Thusoo, et al., 2010), LinkedIn (Sumbaly, Kreps, & Shah, 2013), and Twitter (Lin & Kolcz, 2012). Although the private sector has been ahead in development of data science models (Ransbotham, Gerbert, Reeves, Kiron, & Spira, 2018), scholars also state the value of these models to promote the public good by governmental agencies (Kim, Trimi, & Chung, 2014; Desouza, Dawson, & Chenok, 2020). Nevertheless, there are challenges that must be overcome to bring data science models to fruition.

Data science model deployment is a major challenge on which little research has been done. A recent survey revealed that only 23% of the respondents had at least one data science project in production (Castellanos, Pérez, Varela, Villamil, & Correal, 2019). This deployment failure is often caused by a lack of knowledge on how to deploy data science models and immature deployment procedures (Brethenoux, Vashisth, & Hare, 2018). To fill this knowledge gap, this study sets out to explore how governmental agencies can overcome data science model deployment challenges that result from the interdependencies between model deployment and its context, i.e., the target business process, the model itself and the model development process. To do so, we examine five model deployment cases in a Dutch government organization. The aim of this research is to formulate guidelines that can form a basis for future principles how to successfully deploy data science models. Organizations can use these guidelines as tools or suggestions to solve their own model deployment challenges.

The remainder of this article is structured as follows: section 2 provides a short context description and a summary of previous research on data science model deployment. Section 3 describes the research method and is followed by a summary of the main research findings in section 4. Section 5 discusses the findings and

identifies similarities and differences to the extant literature. Section 6 provides conclusions and describes research limitations.

2 Related work

Data science is conducted in the context of the information value chain. We draw upon the information value chain by Abbasi, Sarker and Chiang (2016), which is a reference model for the collection, validation and storage of data and subsequent creation of information and knowledge. The created knowledge is then used to support decision making in order to take actions. Figure 1 shows where data science model development, model deployment and model use are located within the information value chain.

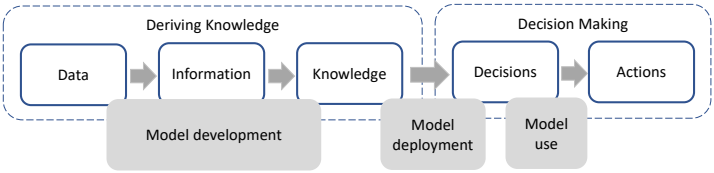


Figure 1: Data science within the information value chain

2.1 Data science model development

Model development takes place in the first phase of the information value chain, deriving knowledge. First many kinds of data are collected, processed and stored, using various combinations of data processing technologies and practices (Chen, Chiang, & Storey, 2012). Then information and knowledge are extracted from the stored data by developing data science models (Provost & Fawcett, 2013; Watson, 2017). The model development process is based on data mining process descriptions (Fayyad, Piatetsky-Shapiro, & Smyth, 1996; Wirth & Hipp, 2000). Data scientists can use all stored data types to develop their statistical, machine learning and other models (Provost & Fawcett, 2013), to produce trends, forecasts, predictions, simulations and other outputs (Watson, 2017). In some cases, model development is done directly on the data stores (Lin & Kolcz, 2012), but in other cases, data scientists work with copies of the stored data (Sumbaly, Kreps, & Shah, 2013; Thusoo, et al., 2010), which are known as analytical sandboxes (Watson, 2017).

2.2 Data science model deployment

Model deployment is situated at the transition between the deriving knowledge phase of the information value chain and the decision-making phase. Model deployment can change business processes. Davenport and Ronanki (2018) state that data science models support individual tasks within target business processes, rather than complete business processes. Such tasks can be automated by incorporating a repeatable data mining process in the target business process (Wegener & Rüping, 2010; Wirth & Hipp, 2000). In addition, the necessary changes in the supporting business applications must be designed (Rupnik & Jaklič, 2009). The production IT infrastructure uses other hardware, standards, programming languages and application frameworks than the analytical sandboxes. The required security levels and processing speeds also differ (John, Olsson, & Bosch, 2020; Jackson, Yaqub, & Li, 2019).

Conversely, during deployment, data science models may need to be adapted or even rebuilt (Sumbaly, Kreps, & Shah, 2013; John, Olsson, & Bosch, 2020). They may be adapted to run without disturbing the surrounding operational applications (Baylor, et al., 2017). During use, machine learning models need sufficient processing speed to immediately provide their results to receiving applications. This could necessitate choosing a faster model with lower output accuracy (John, Olsson, & Bosch, 2020). Additionally, in an automated business process, the data science model must be included in a series of business applications, which necessitates adding application interfaces (Cetinsoy, Martin, Ortega, & Petersen, 2016). Furthermore, the model may have to integrate with reports, or it may have to communicate with users. Thus, it may need a user interface or web interface (John, Olsson, & Bosch, 2020).

Data science models are deployed by software engineers or by users (e.g., Crankshaw, et al., 2017). However, model deployment should be the responsibility of data scientists (Davenport & Malone, 2021). Thus data scientists should start preparing for model deployment during the development phase, by investigating the production IT infrastructure and the necessary changes in the target business process and the business application (Davenport & Malone, 2021; Davenport & Ronanki, 2018). Jackson et al. (2019) and Karamitsos et al. (2020) describe combinations of the data mining process and agile software engineering, to better facilitate model deployment. The data science model deployment process framework

described by John et al. (2020) can fit into this 'hybrid agile data science' process defined by Jackson et al (2019). Other scholars describe using a combination of machine learning application development and systems engineering to solve deployment problems (Martínez-Plumeda, Gómeza, & Hernández-Orallo, 2021).

2.3 Data science model use

Once a machine learning model has been deployed and it is in use within a business process, changes in the input data and in the process environment can influence the working of the model. Therefore, deployed machine learning models need to be monitored continuously (John, Olsson, & Bosch, 2020), by business users (Wegener & Rüping, 2010). However, Davenport and Malone (2021) state that data scientists should do the monitoring. When the working of the machine learning model changes, data scientists need to retrain or redesign the model (John, Olsson, & Bosch, 2020).

3 Research method

From the literature can be concluded that the deployment of data science models is complex (section 2) and not well understood so far (section 1). We thus employed a multiple-case study (Dubé & Paré, 2003). A multiple-case study allows for the exploration of the differences and commonalities across cases to predict similar results across cases (Yin, 2018). In this research, five real-world deployments of data science models are described and compared.

3.1 Selected cases

To promote *external validity,* that focusses on the generalizability of the results (Yin, 2018), we replicated the case studies. In the context of deployment, it was decided to conduct a multiple case study from a single governmental agency. The case studies were selected according to the "literal replication logic" (Dubé & Paré, 2003). Table 1 provides short descriptions of cases. Table 2 presents relevant case characteristics.

Table 1: Short case descriptions

#	Description
Case 1	Predictions for the next two to three years about the economic developments and prospects. Policy makers use the predictions in their decision-making.
Case 2	Scenarios of the effects of current risks that may affect groups of institutions or sectors. Policy makers use this information to prevent or mitigate those risks.
Case 3	Text analysis of annual reporting documents. Remarkable sentences are selected and marked, to support risk analists.
Case 4	In-depth assessments of loan data to support decision making by credit risk experts.
Case 5	Detection of outliers in collected datafiles.

Table 2: Characteristics of the cases

	Case 1	Case 2	Case 3	Case 4	Case 5
Aim	Prediction	Scenarios	Text mining	Risk analysis	Outlier detection
Focus	Strategic	Strategic	Operational	Operational	Operational
Business process	Manual	Manual	Manual	Manual	Automated
Data volume	Small	Small	Small	Large	Small
Data type	Structured	Structured	Unstructured	Structured	Structured
Data sources	External and internal	External and internal	External	External	External
Deployment status	Deployed	Deployed	Deployed	Deployed	Not deployed

3.2 Data collection

Our main information sources are in-depth expert interviews with key-informants. Interviewees were data scientists and users. The data collection started in June 2020 and stretched over a period of four months. In total 11 people are interviewed. Each interview lasted approximately 90 minutes and was conducted online during the COVID-19 pandemic.

To promote *internal validity* as defined by Yin (2018), the interview guide was developed based on the topics of data science model deployment itself and of the resulting deployment effects described in the literature (section 2), i.e. changes in the target business process, changes in the model itself, changes in the model development process and the monitoring and adaptation of models in use. A list of topics/open questions was sent to the interviewees prior to the interview, as

recommended by Maimbo and Pervan (2005). The questions were tailored according to the case. The expert interviews were semi-structured, and the questions were kept open to allow interviewees to speak freely.

Yin (2018) suggests triangulation to promote *construct validity*. Within the case studies, different data sources were therefore used. Additionally, for each case background information from project documentation, reports and memos, presentations and internal and external organizational communications was collected and summarized.

In order to minimize errors and biases, the *reliability* of the case studies was promoted by establishing a case study database. There, we stored all information about the data collection process, the data itself and the case study results. This helps to provide the same results in repeated trials (Yin, 2018).

3.3 Data analysis

The interviews were recorded and transcribed, coded and then analyzed using ATLAS.ti. We used first-level coding (Miles, Huberman, & Saldana, 2013) to identify and relate similar statements. The interviews were coded bottom-up, without using predefined codes. The codes were summaries of the interview quotes and were placed in code groups per subject and then gathered in main code groups representing main subjects. The code groups were gradually added with every interview. New code groups were added as needed. Eventually fifteen main code groups were defined, each containing two to eleven code groups. One example is the main code group Data Science Application or DSA (i.e. data science model), containing the code groups DSA input data programming, DSA algorithms, DSA output data programming, DSA size, DSA tooling, DSA machine learning basis and DSA traditional basis. Other main code groups represent various data science process steps within the target business process, model version management, encountered deployment challenges and deployment recommendations made by the interviewees. The code groups and main code groups were visualized in networks and the following themes were derived: changes in the data science model, model version management, the model development process, the target business process, incorporation of the model in the target business process, deployment challenges and model deployment recommendations. Then the interview analysis results were compared to and supplemented by the collected background documentation and for

each case a case descriptions was created. Finally, the case descriptions were compared to each other and similarities and differences between cases were analysed.

4 Results

In the research cases data science model deployment led to changes in the target business process, changes in the models themselves, maintenance of deployed models in the model development process and a feedback loop between the target business process and the model development process. These four model deployment effects are further described below, with the related challenges and recommendations that were mentioned in the case interviews.

4.1 Adaptations in the business process

In all cases the model deployment resulted in the incorporation of a data science subprocess in the target business process. This data science subprocess automated one of the target business process tasks by using the data science model, and consisted of preparation of the model input data that were collected from the processed and stored data, definition of the model input parameters, limited adaptations of the model algorithms, running the model, validation of the model output data, interpretation of the results and communication of the outcomes to users or other business process steps. Interviewees recommended to make the data science subprocess fixed and stable, and preferably automated.

The strategic business processes in the predictions and scenarios cases contained the data science subprocess only. The operational business processes in the text mining, risk analysis and outlier detection cases contained additional business process steps. The respondents recommended adapting these additional process steps to provide input to and receive output from the data science subprocess, before developing the data science model. They also recommended incorporating the data science subprocess in the target business process before developing the model.

Only the outlier detection case had an automated business process (Table 2).
The business applications were adapted to exchange input and output data with the data science model. The respondents recommended to do this before developing the model. Adapting the business applications was challenging because the data

scientists lacked the necessary software engineering skills. In the interviews cooperation with software engineers was recommended.

In all cases the data science models were developed in a separate sandbox IT environment. The deployed models were run in the sandbox as well, because the production IT infrastructure lacked facilities to run data science models. As a result the operational business processes became distributed over two different IT environments: the data science subprocess was run in the sandbox and the other business process steps were run on the production IT infrastructure. This necessitated model input and output data transport between the two IT environments. This data transport was challenging because the two IT environments were strictly separated for security reasons. Another challenge was that the sandbox did not provide the continuity guarantees that were required for business-critical processes.

4.2 Adaptation of the data science models

As a result of deployment, the data science models in the operational business processes were adapted to achieve the required processing speed (risk analysis case) or to communicate with users (text mining case). Adaptation of the models in the manual strategic business processes (predictions and scenarios cases) was not necessary as the models did not need to exchange data with other applications and because the data scientists also were the users of their models so they did not need a user interface.

4.3 Maintenance of data science models

In all cases with a deployed model, the models could be adapted because of user feedback and new user requirements, new business theories and situations, new input data types, new strategic themes, new available data science algorithms or errors. This model maintenance was considered to be part of the model development process. The models could be adapted at the request of users and on the initiative of small teams of data scientists, who also have business knowledge.

The maintenance was carried out ad hoc (risk analysis case, text mining case), especially for smaller changes, in development projects (predictions case, text mining case) or as part of a medium-term development plan (scenarios case). Having such a plan was recommended, as it helps to keep the model well-structured and maintainable. In the risk analysis case, keeping the model modular and maintainable was a challenge caused by the lack of necessary software engineering skills. As a consequence, getting software engineering skills or cooperating with software engineers was recommended.

4.4 Feedback loop

In all cases, as a result of model deployment a feedback loop was established between the model development process and the target business process. Based on the experience of using the model in the business process, the model was improved in the development process. Subsequently, the model was used in the target business process again. In the cases with an operational business process, obtaining user feedback and cooperation was a challenge, but was strongly recommended as it was regarded as essential to have the deployed models used and improved.

In all cases, the feedback loop was enabled and supported by the establishment of a master model and a master model version management process. The master model was the tested and stable model version that forms the basis for all other model versions. Model improvement started by making a copy of the current master model. Permanently used model adaptations were merged into the master model again. One-off adaptations will be retained, but are not merged into the master model. Establishing a master model and careful management of the master model versions were strongly recommended.

4.5 Impact on strategic and operational business processes

Table 3 summarises the deployment effects that were found in the two cases with a strategic business process, in the two cases with a manual operational business process and in the case with an automated operational business process. In Table 3 can be seen that model deployment had more impacts on the business process and the data science model in the operational business processes than in the strategic business processes.

Table 3: Deployment effects in strategic and operational business processes

Deployment effect	**Strategic business process, manual Cases 1 and 2**	**Operational business process, manual Cases 3 and 4**	**Operational business process, automated Case 5**
Changes in target business process	Data science subprocess	Data science subprocess	Data science subprocess
	-	Changes in other business process steps	Changes in other business process steps
	-	-	Changes in business applications
	Business process in sandbox	Business process in sandbox and IT production	Business process in sandbox and IT production
Changes in data science model	-	Changes in model	- (model not yet deployed)
Model maintenance	In development process	In development process	In development process
Feedback loop	Feedback loop	Feedback loop	Feedback loop

5 Discussion

The research cases provide an overview of possible data science model deployment effects on the target business process, on the model itself and on the model development process.

The *adaptations in the business processes* resulting from model deployment in the research findings are in part consistent with prior literature and partly complementary. The incorporation of the data science subprocess in the target business process is consistent with the implementation of a repeatable data mining process mentioned by Wirth and Hipp (2000). A description of the data science subprocess or repeatable data mining process complements the literature. The data science subprocess contains the same activities as described in the data mining reference processes by Wirth and Hipp (2000). However, the data science subprocess is fixed and stable instead of iterative and flexible. In addition, in the data science subprocess the adaptations of the deployed model are limited to the minimum necessary to achieve the goals of the business process, while the data mining reference process describes the development of a complete data science model (Wirth & Hipp, 2000). The adaptations of the business process steps and business applications in operational business processes are consistent with the conclusions of Rupnik and Jaklič (2009).

The deployment of data science models in a sandbox is not described in the literature, which could be explained by the resulting challenges in the research findings.

The *changes in the data science models* resulting from model deployment in the research findings are consistent with the deployment changes in the models described by prior literature (John, Olsson, & Bosch, 2020; Baylor, et al., 2017; Cetinsoy, Martin, Ortega, & Petersen, 2016).

With regard to *maintenance*, the research results are different to extant literature. In all research cases examined in this study, maintenance of deployed data science models is considered to be part of the model development process. In contrast, previous studies (John, Olsson, & Bosch, 2020) consider model maintenance as part of the model deployment processes.

Concerning the *feedback loop*, our study presents interesting results. In all researched cases, the goals of the feedback loops are model improvements based on user experiences. In the literature, feedback loops are described for machine learning models only, to correct errors in the working of the models that are caused by changes in the input data (John, Olsson, & Bosch, 2020). In the two cases with a machine learning model (Table 2) such a feedback loop was not present. An explanation for this could be that the text mining model is in use for just a short time and the outlier detection model is not deployed yet.

The research findings regarding the *differences in deployment effects in strategic and operational business processes* are an addition to the extant literature.

6 Conclusions and limitations

The resulting *guidelines* derived from the recommendations made by the interviewees are in part consistent with prior literature and in part complementary. Adapting the business process and business applications before building the model is consistent with recommendations in prior literature (Davenport & Ronanki, 2018; Davenport & Malone, 2021; Rupnik & Jaklič, 2009). Working with a mixed team of data scientists, software engineers and users is consistent with recommendations of Davenport & Ronanki (2018) and Jackson et al. (2019). Establising the data science

subprocess before developing the model, making the data science subprocess fixed and stable and establishing a feedback loop for model improvement based on user experiences are additional guidelines to the extant literature. So are the establishment of a master model and careful management of the master model versions, and the definition of a medium-term master model development plan.

This study comes with limitations. The case studies were carried out in one Dutch government organization. Therefore, the results may not be transferable to other government organizations and to commercial organizations. The small number of cases may further limit transferability (Yin, 2018). Further research is needed to assess generalizability of the research findings to other organizations. Despite these limitations this study provides valuable insights for both practitioners as well as academics in the effects and challenges of data science model deployment.

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The Effects of General and Mobile Online Shopping Skilfulness and Multichannel Self-Efficacy on Consumer Showrooming Behaviour

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Abstract Although showrooming behaviour is a characteristic aspect of modern omnichannel retailing, our understanding of its antecedents remains limited. In this study, we aim to address this gap in prior research by examining how showrooming behaviour is affected by three different kinds of perceived consumer capabilities: general online shopping skilfulness, mobile online shopping skilfulness, and multichannel self-efficacy. The examination is done by utilising data from 1,024 Finnish consumers, which was collected with an online survey in 2021 and is analysed with structural equation modelling (SEM). In summary, we find mobile online shopping skilfulness to have a strong positive effect on showrooming behaviour, the total effect of general online shopping skilfulness to be statistically not significant, and the effect of multichannel self-efficacy to be negative. In addition, we find several interesting gender and age differences. We conclude the paper with a detailed discussion of the findings from both theoretical and practical perspectives.

Keywords: general online shopping skilfulness, mobile online shopping skilfulness, multichannel self-efficacy, showrooming behaviour, gender and age differences.

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1 Introduction

During the past decade, we have witnessed the emergence of so-called omnichannel retailing, which refers to the integration of multiple retail channels and other touchpoints between retailers, brands, and consumers in order to provide consumers with a single seamless and consistent customer experience (Rigby, 2011; Brynjolfsson et al., 2013; Verhoef et al., 2015; Akter et al., 2021). One characteristic aspect of this novel type of retailing is so-called showrooming behaviour, which is defined by Rapp et al. (2015) as "a practice whereby consumers visit a brick-and-mortar retail store to (1) evaluate products or services first-hand and (2) use mobile technology while in-store to compare products for potential purchase via any number of channels". Currently, this practice is very common. For example, in a recent study by Shopify (2021), 53% of the surveyed consumers said that they are likely to practise showrooming over the next year. However, in spite of its commonness and some prior studies on it (Sahu et al., 2021), our understanding of the antecedents of showrooming behaviour remains limited (Daunt & Harris, 2017), making it difficult for retailers to control and manage showrooming behaviour in order to maximise its potential advantages, such as better customer experience, and minimise its potential disadvantages, such as losses in sales (Schneider & Zielke, 2020). More specifically, there seems to exist a clear gap in our understanding of how various consumer capabilities, or consumer beliefs about and perceptions of these capabilities, affect their showrooming behaviour (Sahu et al., 2021). In this study, we aim to address this gap in prior research by examining how showrooming behaviour is affected by three different kinds of perceived consumer capabilities: general online shopping skilfulness, mobile online shopping skilfulness, and multichannel self-efficacy. In addition, as several prior studies have suggested showrooming behaviour to be affected by demographic variables like gender and age (Dahana et al., 2018; Burns et al., 2019; Sahu et al., 2021), we also examine the potential gender and age differences in the effects of these perceived consumer capabilities on showrooming behaviour as well as in the perceived consumer capabilities and showrooming behaviour themselves. This all is done by utilising data from 1,024 Finnish consumers, which was collected with an online survey in 2021 and is analysed with structural equation modelling (SEM).

After this introductory section, we briefly present our research model in Section 2. The methodology and results of the paper are reported in Sections 3 and 4, and the results are discussed in more detail in Section 5. Finally, the paper concludes with a brief discussion of the limitations of the present study and some potential paths for future research in Section 6.

2 Research Model

In our research model, which is illustrated in Figure 1, we hypothesise showrooming behaviour to be positively affected by three different kinds of perceived consumer capabilities: general online shopping skilfulness, mobile online shopping skilfulness, and multichannel self-efficacy. Of these, general online shopping skilfulness refers to the general online shopping skills of consumers, such as their ability to search for information and place orders over the Internet, whereas mobile online shopping skilfulness refers to the online shopping skills of consumers concerning transactions that are completed specifically by using smartphones. In turn, multichannel self-efficacy is defined by Chiu et al. (2011) as "the ability and confidence of consumers to employ multiple channels, including online and brick-and-mortar stores, to finish a transaction, starting with information search and ending in purchase".

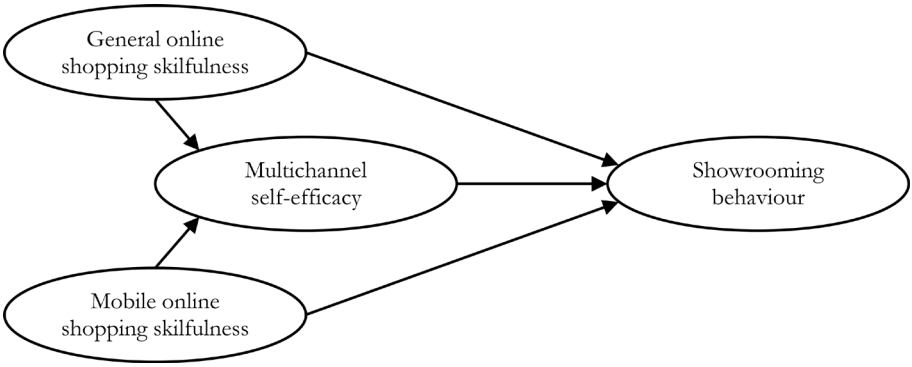


Figure 1: Research model

Of these perceived consumer capabilities, general online shopping skilfulness obviously acts as a critical prerequisite for showrooming behaviour. Without it, consumers would not be able to utilise online channels for information search and ordering, but their choice of channels would be limited to offline channels only.

However, in addition to general online shopping skilfulness, showrooming behaviour requires consumers to possess more specific mobile online shopping skilfulness in order for them to be able to search for information and potentially place orders while in-store by using their smartphones. Moreover, we argue that in addition to general and mobile online shopping skilfulness, showrooming behaviour requires consumers to possess more comprehensive multichannel self-efficacy in order for them to have confidence in their capabilities to use not only one but multiple channels during the purchasing process, such as when first physically examining the product at a brick-and-mortar store and then searching for more information about it and potentially ordering it from an online store. This argument also gains support from a prior study by Arora et al. (2017), who found multichannel self-efficacy to positively affect showrooming intention, albeit not directly but indirectly via perceived behavioural control. Finally, in our research model, we also hypothesise general and mobile online shopping skilfulness to have positive effects on multichannel self-efficacy because the more skilful consumers are in using online channels, the more confidence they are also likely to have in their capabilities of using these channels in addition to offline channels during the purchasing process.

3 Methodology

The data for testing the research model was collected from Finnish consumers in 2021 with an online survey, in which the model constructs were measured reflectively by three items each. The items measuring general online shopping skilfulness (GOSS) were adapted from the Internet shopping skill scale by Rose et al. (2012), whereas the items measuring mobile online shopping skilfulness (MOSS) were adapted from the mobile skilfulness scale by Lu and Su (2009). In turn, the items measuring multichannel self-efficacy (MCSE) were adapted from the study by Chiu et al. (2011), whereas the items measuring showrooming behaviour (SRB) were adapted from the study by Li et al. (2018). The wordings of these items (before the translation from English to Finnish) are reported in Appendix A. The measurement scale was a standard seven-point Likert scale (1 = strongly disagree … 7 = strongly agree). The respondents also had the option not to respond to a specific item, which resulted in a missing value.

The collected data was analysed with covariance-based structural equation modelling (CB-SEM) by using the Mplus version 8.8 software (Muthén & Muthén, 2022) and following the guidelines by Gefen et al. (2011) for SEM in administrative and social science research. As the model estimator, we used the MLR option of Mplus, which stands for maximum likelihood estimator robust to non-normal data. The potential missing values were handled by using the FIML option of Mplus, which stands for full information maximum likelihood and uses all the available data in model estimation. The potential gender and age differences were examined with multiple group analysis (MGA) by following the testing procedure proposed by Steenkamp and Baumgartner (1998) for establishing measurement invariance. In it, increasingly strict constraints on parameter equality are added across the groups and the fit of the resulting constrained model is compared to the fit of the unconstrained model. If the constraints result in no statistically significant deterioration in model fit, then the hypothesis on the specific type of measurement invariance is supported. Configural invariance is tested by estimating the model separately in each group while constraining only the simple model structure as equal across the groups, whereas metric and scalar invariance are tested by additionally constraining the indicator loadings and indicator intercepts as equal across the groups. After this, the differences in the model constructs can be tested by examining their estimated mean scores in each group. Of the groups, one is typically specified as a reference group, in which the construct mean scores are fixed to zero and against which the construct mean scores of the other groups are compared. In addition, the differences in the effects between the model constructs can be tested by constraining the estimated effect sizes as equal across the groups. As a statistical test for examining the potential deteriorations in model fit, we used the χ^2 test of difference, in which the value of the test statistic was corrected with the Satorra-Bentler (2001) scaling correction factor (SCF) due to the use of MLR as the model estimator. However, because the χ^2 test of difference is known to suffer from a similar sensitivity to sample size as the χ^2 test of model fit, we also considered the potential changes in the model fit indices, as suggested by Steenkamp and Baumgartner (1998).

4 Results

In total, we received 1,028 responses to our online survey, of which four responses had to be dropped due to missing data. Thus, the sample size of this study was 1,024 responses. The descriptive statistics of this sample in terms of the gender, age, and income distributions of the respondents as well as the reference gender, age, and income distributions of the Finnish population (Statistics Finland, 2022; Finnish Tax Administration, 2022) are reported in Table 1, showing that the sample had good representativeness. In the following three subsections, we first assess the reliability and validity of the estimated model at both indicator and construct levels, then report the model fit and model estimates, and finally examine the potential gender and age differences.

Table 1: Sample statistics and the reference statistics of the Finnish population

	Sample (N)	Sample (%)	Finland (%)
Gender			
Man	497	48.5	50.3
Woman	527	51.5	49.7
Age			
18–29 years	188	18.4	19.3
30–39 years	213	20.8	18.1
40–49 years	194	18.9	16.9
50–59 years	197	19.2	17.6
60–75 years	232	22.7	28.1
Personal taxable income			
Under 20,000 €	304	34.3	39.4
20,000–39,999 €	349	39.3	35.7
40,000 € or over	234	26.4	25.0
Missing	137	–	–

4.1 Model Reliability and Validity

Construct reliabilities were assessed by using the composite reliabilities (CR) of the constructs (Fornell & Larcker, 1981), which are commonly expected to be greater than or equal to 0.7 (Nunally & Bernstein, 1994). The CR of each construct is reported in the first column of Table 2, showing that all the constructs met this criterion. In turn, construct validities were assessed by examining the convergent

and discriminant validities of the constructs by using the two criteria proposed by Fornell and Larcker (1981). They are both based on the average variance extracted (AVE) of the constructs, which refers to the average proportion of variance that a construct explains in its indicators. In order to have acceptable convergent validity, the first criterion expects each construct to have an AVE of at least 0.5. This means that, on average, each construct should explain at least half of the variance in its indicators. The AVE of each construct is reported in the second column of Table 2, showing that all the constructs met this criterion. In order to have acceptable discriminant validity, the second criterion expects each construct to have a square root of AVE greater than or equal to its absolute correlations with the other model constructs. This means that, on average, each construct should share at least an equal proportion of variance with its indicators than it shares with these other model constructs. The square root of AVE of each construct (on-diagonal) and the correlations between the constructs (off-diagonal) are reported in the remaining columns of Table 2, showing that this criterion was also met by all the constructs.

Table 2: Construct statistics (* = p < 0.001)**

Construct	CR	AVE	GOSS	MOSS	MCSE	SRB
GOSS	0.915	0.783	0.885			
MOSS	0.941	0.842	0.617***	0.917		
MCSE	0.910	0.772	0.837***	0.639***	0.879	
SRB	0.863	0.679	0.462***	0.774***	0.414***	0.824

Finally, indicator reliabilities and validities were assessed by using the standardised loadings of the indicators, which are reported in Table 3 together with the means and standard deviations (SD) of the indicator scores as well as the percentages of missing values. In the typical case of each indicator loading on only one construct, the standardised loading of each indicator is commonly expected to be statistically significant and greater than or equal to 0.707 (Fornell & Larcker, 1981). This is equivalent to the standardised residual of each indicator being less than or equal to 0.5, meaning that at least half of the variance in each indicator is explained by the construct on which it loads. The only indicator that did not quite meet this criterion was SRB3, but we decided not to drop it from the model because it was not found to compromise the overall reliability or validity of the SRB construct (cf. Table 2).

Table 3: Indicator statistics (* = p < 0.001)**

Indicator	Mean	SD	Missing	Loading
GOSS1	5.775	1.308	0.0%	0.887***
GOSS2	5.470	1.429	0.5%	0.899***
GOSS3	5.664	1.296	0.3%	0.868***
MOSS1	5.284	1.754	0.1%	0.921***
MOSS2	5.175	1.760	0.4%	0.907***
MOSS3	5.355	1.743	0.3%	0.924***
MCSE1	5.977	1.166	0.1%	0.870***
MCSE2	5.772	1.299	0.0%	0.892***
MCSE3	5.783	1.253	0.4%	0.874***
SRB1	4.933	1.871	0.1%	0.871***
SRB2	4.997	1.847	0.2%	0.892***
SRB3	4.147	1.992	0.7%	0.695***

4.2 Model Fit and Model Estimates

The results of model estimation in terms of the standardised effect sizes and their statistical significance, the proportions of explained variance (R^2), as well as model fit are reported in Figure 2. Model fit was assessed by using the χ^2 test of model fit and four model fit indices recommended in recent methodological literature (Hu & Bentler, 1999): the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardised root mean square residual (SRMR). Of them, the χ^2 test of model fit rejected the null hypothesis of the model fitting the data, which is common in the case of large samples (Bentler & Bonett, 1980). In contrast, the values of the four model fit indices all clearly met the cut-off criteria recommended by Hu and Bentler (1999): CFI $\geq$ 0.95, TLI $\geq$ 0.95, RMSEA $\leq$ 0.06, and SRMR $\leq$ 0.08. Thus, we consider the overall fit of the model acceptable. We also found no serious signs of multicollinearity or common method bias. The variance inflation factor (VIF) scores calculated from the factor scores were all clearly less than ten (Hair et al., 2018), and the Harman's single factor test (Podsakoff et al., 2003) suggested a very bad model fit ($\chi^2(54) = 5{,}695.861$, $p < 0.001$, CFI = 0.067, TLI = 0.000, RMSEA = 0.319, SRMR = 0.124).

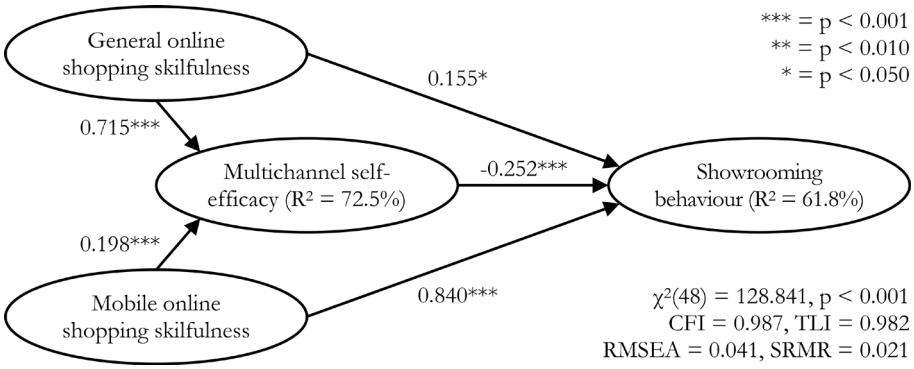


Figure 2: Model estimates and model fit

Of the perceived consumer capabilities, both GOSS and MOSS were found to have statistically significant and positive effects on MCSE, with GOSS having a stronger effect than MOSS, whereas MCSE together with GOSS and MOSS were found to have statistically significant effects on SRB, with MOSS having a strong positive effect, GOSS having a weak positive effect, and MCSE having a negative effect. However, when also considering the indirect effects of GOSS and MOSS on SRB via MCSE, the total effect of GOSS on SRB was found to be statistically not significant (-0.025), whereas the total effect of MOSS on SRB remained statistically significant and positive (0.790***). In total, the model explained 72.5% of the variance in MCSE and 61.8% of the variance in SRB.

4.3 Gender and Age Differences

In order to examine the potential gender and age differences, the sample was first split into four groups to be compared against each other: men aged under 50 years (N = 258), women aged under 50 years (N = 337), men aged 50 years or over (N = 239), and women aged 50 years or over (N = 190). The threshold for the age split was determined on an empirical basis, as it resulted in the evenest split and there was also a distinct drop in the scores of many measurement items at around 50 years of age. After this, measurement invariance across the groups was tested. The results of these tests are reported in Table 4. As can be seen, the tests supported the hypothesis on both configural and full metric invariance but only partial scalar invariance. The intercepts that were not found to be invariant across the groups were those of SRB3 among men aged under 50 years and women aged under 50 years, SRB2 among

women aged 50 years or over, and GOSS3 among men aged 50 years or over. However, this partial scalar invariance can only be considered to compromise the mean score comparisons concerning the SRB construct between men aged under 50 years and women aged 50 years or over as well as between women aged under 50 years and women aged 50 years or over. In those cases, the SRB construct is measured by only one indicator that has both an invariant loading and an invariant intercept across the compared groups (cf. Steenkamp & Baumgartner, 1998).

Table 4: Measurement invariance tests (1 = men aged under 50 years, 2 = women aged under 50 years, 3 = men aged 50 years or over, 4 = women aged 50 years or over)

Invariance	χ^2	df	SCF	CFI	TLI	RMSEA	SRMR	$\Delta\chi^2$	Δdf	p
Configural	346.427	192	1.3179	0.975	0.965	0.056	0.033	–	–	–
Full metric	382.747	216	1.3019	0.973	0.966	0.055	0.050	35.559	24	0.061
Full scalar	473.526	240	1.2693	0.961	0.958	0.062	0.057	105.286	24	< 0.001
Partial scalar (SRB3 in 1)	445.949	239	1.2702	0.966	0.962	0.058	0.056	70.073	23	< 0.001
Partial scalar (SRB3 in 2)	429.931	238	1.2713	0.968	0.965	0.056	0.055	49.722	22	0.001
Partial scalar (SRB2 in 4)	421.329	237	1.2724	0.970	0.966	0.055	0.055	39.011	21	0.010
Partial scalar (GOSS3 in 3)	414.507	236	1.2728	0.971	0.967	0.054	0.053	30.554	20	0.061
Full path	422.891	251	1.2881	0.972	0.970	0.052	0.060	11.212	15	0.737

The results of the construct mean score comparisons across the groups are reported in a tabular form in Table 5 and a graphical form in Figure 3. In terms of gender, women were found to have higher mean scores than men in MOSS, MCSE, and SRB among those aged under 50 years but higher mean scores in GOSS among those aged 50 years or over. In turn, in terms of age, those aged 50 years or over were found to have lower mean scores in all the four constructs in comparison to those aged under 50 years, of which the difference in GOSS was more pronounced among men than women, whereas the difference in SRB was more pronounced among women than men. Finally, the last row in Table 4 reports the result of the full path invariance test, which suggested that, overall, there were no statistically significant differences across the groups in the effects between the model constructs.

Table 5: Construct mean scores (1 = men aged under 50 years, 2 = women aged under 50 years, 3 = men aged 50 years or over, 4 = women aged 50 years or over)

	2 vs. 1	3 vs. 1	4 vs. 1	3 vs. 2	4 vs. 2	4 vs. 3
GOSS	0.085	-0.610***	-0.283*	-0.695***	-0.368**	0.327*
MOSS	0.271**	-1.016***	-0.700***	-1.287***	-0.971***	0.316
MCSE	0.204**	-0.208*	-0.051	-0.413***	-0.256*	0.157
SRB	0.402***	-0.938***	-0.957***	-1.341***	-1.360***	-0.019

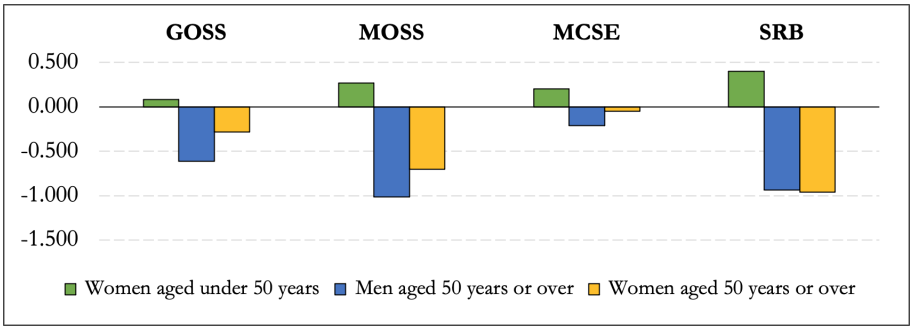


Figure 3: Construct mean scores (reference group = men aged under 50 years)

5 Discussion and Conclusion

In this study, we examined the effects of general online shopping skilfulness, mobile online shopping skilfulness, and multichannel self-efficacy on showrooming behaviour as well as their potential gender and age differences. During this examination, we made three main findings. First, of the examined perceived consumer capabilities, we found mobile online shopping skilfulness to have a strong positive effect on showrooming behaviour, whereas the total effect of general online shopping skilfulness was found to be statistically not significant. In addition, contrary to our hypothesis, we found the effect of multichannel self-efficacy to be negative instead of positive. This negative effect highlights the importance of having general and mobile online shopping skilfulness as controls when examining the effect of multichannel self-efficacy on showrooming behaviour. Without such controls, our findings would have been similar to those by Arora et al. (2017), suggesting only a positive effect (cf. the positive correlation between multichannel self-efficacy and showrooming behaviour in Table 2). In other words, this negative

effect reflects other mechanisms through which multichannel self-efficacy affects showrooming behaviour in addition to consumers with higher multichannel self-efficacy also having higher online shopping skilfulness. Two potential examples of such mechanisms are the effects of multichannel self-efficacy on showrooming behaviour via trust and risks. Related to these, Kim and Kim (2005) found online transaction self-efficacy to affect positively the trust toward and negatively the risks of online shopping. Multichannel self-efficacy can be expected to exhibit similar effects because consumers with lower multichannel self-efficacy are likely to be less confident and more uncertain about their use of various offline and online channels. In turn, Daunt and Harris (2017) found lower trust to result in more showrooming behaviour, partly due to the pivotal role of trust in promoting customer loyalty (Harris & Goode, 2004), whereas Arora et al. (2017) have suggested that higher risks result in more showrooming behaviour because consumers typically try to reduce them by spending more time searching for information, which may also involve a visit to a brick-and-mortar store in order to physically examine the products. Thus, both these mechanisms result in a negative effect of multichannel self-efficacy on showrooming behaviour.

Second, although general online shopping skilfulness was found to have no statistically significant total effect on showrooming behaviour, we found it to have a positive effect on multichannel self-efficacy together with mobile online shopping skilfulness. If one assumes a positive association between experience and skilfulness, this finding is largely in line with the prior study by Chiu et al. (2011), who found Internet experience and vicarious experience to positively affect multichannel self-efficacy. Third, in terms of the potential gender and age differences, we found no differences in the effects between the constructs of our research model. However, we found women aged under 50 years to have the highest online shopping skilfulness and multichannel self-efficacy, which also resulted in them practising showrooming most commonly. In addition, we found consumers aged under 50 years to have higher online shopping skilfulness and multichannel self-efficacy in comparison to consumers aged 50 years or over, once again also resulting in them practising showrooming more commonly. These findings conflict with the prior studies by Burns et al. (2019) and Dahana et al. (2018), who found no gender differences in showrooming behaviour. This may be explained by our more detailed examination of also the interactions between gender and age. However, the findings are in line

with the prior study by Dahana et al. (2018), who found showrooming behaviour to be more prevalent among younger consumers.

From a theoretical perspective, the aforementioned findings provide valuable new insights into the antecedents of showrooming behaviour and multichannel self-efficacy as well as their potential gender and age differences. From a practical perspective, they also have important implications for the retailers in the novel omnichannel environments, who can utilise them to either promote or reduce showrooming behaviour through manipulating the perceived consumer capabilities, while also simultaneously considering the potential negative side-effects that higher multichannel self-efficacy may have on showrooming behaviour via trust and risks. Moreover, the retailers can also try to steer showrooming behaviour from so-called competitive showrooming to so-called loyal showrooming, in which the final purchase is made from the same retailer whose brick-and-mortar store was visited (Schneider & Zielke, 2020).

6 Limitations and Future Research

We consider this study to have four main limitations. First, the study was conducted by focusing only on Finnish consumers, which may limit the generalisability of its findings. Second, our operationalisation of showrooming behaviour focused only on the use of a smartphone for information search while in-store but not on whether a product that was physically examined offline was actually purchased online, which is something that many may consider a characteristic aspect of showrooming behaviour, although it is not a definitive aspect of showrooming behaviour according to Rapp et al. (2015). Third, our measurement of showrooming behaviour was based on subjective self-reporting instead of objective observations, such as real usage data. Fourth, in our research model, we mainly focused on perceived online consumer capabilities instead of perceived offline consumer capabilities, such as in-store shopping savviness, which was found to have a positive effect on showrooming behaviour in the prior study by Daunt and Harris (2017). Future studies should address these limitations by replicating the study in other countries while revising its research model as well as the operationalisation and measurement of its constructs.

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Appendix A: Item Wordings

Item	Wording
GOSS1	I consider myself knowledgeable about good search techniques for online shopping.
GOSS2	I am extremely skilled at online shopping.
GOSS3	I know how to find what I am looking for when shopping online.
MOSS1	I feel confident using a smartphone to complete an online shopping transaction effortlessly.
MOSS2	I am able to use a smartphone to complete an online shopping transaction in a short time especially if I get some guidance.
MOSS3	I am able to use a smartphone to complete an online shopping transaction in a short time especially if I have used a similar store or system before.
MCSE1	I am confident of my ability to use both online and offline channels while shopping.
MCSE2	I am able to utilise both online and offline channels in the process of purchase.
MCSE3	I believe I am good at evaluating the choices of online and offline channels while shopping.
SRB1	I use mobile devices to find better prices for products online.
SRB2	I often use mobile devices to find more information about products in the store.
SRB3	I use mobile devices to look for information about products while still in the store.

CUSTOMER-BRAND RELATIONSHIPS IN THE CONTEXT OF DIGITAL BRANDS

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Abstract This qualitative study investigates customer-brand relationships between customers and digital brands. This study aims to describe different digital brand relationship types, and their manifestations among young adult customers. The data collection was conducted in 2021 by interviewing fourteen Finnish adults aged 22-31 years. The findings categorize the customer-brand relationships into four relationship types, according to the relationship strength from weak to strong. *Brand liking* lacks emotions and is characterized by low commitment towards a digital brand. *Brand attachment* includes having a slight barrier of digital brand replacement, and emotions towards the brand are weak. *Brand loving* denotes that a beloved digital brand is favored in the long term, but the brand is not considered irreplaceable. *Brand addiction* occurs when a customer has an irreplaceable, intimate, and dependent relationship with the digital brand. All the found relationship types need further investigation in future research.

Keywords: digital brands, customer-brand relationships, brand liking, brand attachment, brand love, brand addiction.

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1 Introduction

Brands are significant to customers in their everyday lives (Fournier 1998) and are constantly encountered everywhere in the digitalized world. The use of information systems has increased in the past few years (Ågerfalk et al. 2020) and, in certain situations, digital interaction displaces physical encounters between customers and brands (Geiger et al. 2021). Digital encounters arise due to new service innovations and the evolvement of traditional services. The online environment has many advantages over the physical world (Kemppainen et al. 2021), and digital platforms can have even societal power (Bonina et al. 2021). At the same time, today's brands have evolved into interactive entities, which are communicating and creating customer-brand relationships (Veloutsou & Guzmán 2017). Digital brand has an online presence (Rowley 2009) and is experienced through devices, platforms, and applications – often without any physical appearance. Hence, the question of how customers perceive their relationships with these intangible digital brands is of importance to companies and academics. The specific features and dimensions of these relationships, compared to the "traditional" brands with physical existence, are of particular interest.

This qualitative study investigates customer-brand relationships in the context of digital brands. Studies on the topic are scarce as previous research has mainly focused on relationships between customers and physical brands (Fournier 1998; Elhajjar et al. 2021; Kim & Kwon 2011; Park et al. 2010; Carroll & Ahuvia 2006). The digital aspect has been included as a context of relationship creation environment (Confos & Davis 2016), in online brand communities (Badrinarayanan et al. 2014; Dessart et al. 2015), and as a commercial platform (Roggeveen et al. 2021). The relationships between customers and digital brands have been investigated only in a few studies: In the context of search engine brands (Morgan-Thomas & Veloutsou 2013; Veloutsou & McAlonan 2012) and by exploring the relationships' quality aspect on social networks sites (Pentina et al. 2013). In this study, we investigate digital brands without concentrating on any specific brand or category but based on the digital brands which are perceived as most important by the study participants. This research contributes to the above noted gap in research on customer-digital brand relationships, their relationship types and manifestations of these relationships.

This paper first discusses previous studies on customer-brand relationship types in Section 2 below. Next, Section 3 reports the collection of data and analysis. The findings of the empirical study are presented in Section 4, and finally, Section 5 discusses the contributions and managerial implications of this study and provides suggestions for future research.

2 The relationship between a customer and digital brand

The customer-brand relationship is constructed in the customer's emotions, cognitions, and activities towards the brand (Strandvik & Heinonen 2013). This relationship is similar to a relationship between people (Fourner 1998), and thus it includes extensive emotional scales (Mrad 2018), from love to antipathy (Shimp & Madden 1988). These relationships can also evolve or decline in a process-like manner (Fournier 1998).

2.1 Relationship types between a customer and a brand

The literature does not provide a systematic and solid synthesis of customer-brand relationships (Khamitov et al. 2019), although various concepts have been used to depict these relationships. Used concepts include, for example, relationship *forms* (Fournier 1998), *metaphors* (Kim & Kwon 2011) and *types* (Fajer & Schouten 1995; Khamitov et al. 2019). In this study, we use the concept of types, which is in line with the descriptions provided by Fajer & Schouten (1995) and Khamitov et al. (2019).

From the previous customer-brand relationship literature, four main relationship types can be identified. These are, listed from the weakest to the strongest: *brand liking* (Fajer & Schouten 1995), *brand attachment* (Park et al. 2010), *brand love* (Rahman et al. 2021), and *brand addiction* (Mrad 2018).

Brand liking (or 'casual friends') is a relationship type where customers like the brand but do not feel more committed to it, if compared with other brands (Fajer & Schouten 1995). Fournier (1998) defined in her study a relationship form termed 'casual friends/buddies', which represented low affectivity, and in which customer expectations had only little reciprocity from the brand. Despite these considerations, the brand was considered as a friend. Kim & Kwon (2011) used a metaphor of

'casual buddies' to depict a low intensity relationship, following Fournier's (1998) description. Earlier literature also explored the term brand liking in the context of measuring brand assets from a customer perspective (Anselmsson et al. 2008). To summarize, the term brand liking has been used quite scarcely in earlier studies.

Brand attachment is a relationship type characterized by loyalty (Khamitov et al. 2019). It is a construct manifesting the bond between a customer and a brand, and it is indicated through self-brand connection and prominence (Park et al. 2010). Further, Jatpura et al. (2014) link three dimensions, namely emotions, brand connection, and importance, to brand attachment. According to Khamitov et al. (2019), brand attachment arises from intensive emotional captures, and is of emotional nature, but of cognitive representation. Fajer and Schouten (1995) present a relationship type called 'close friends' ('multi-brand resurgent loyalty'), which has many similarities with brand attachment. In their study, the brand is considered as a good friend with a customer. However, this comes without exclusive loyalty, and thus customers can use multiple brands at the same time. (Fajer & Schouten 1995.) Also, Fournier (1998) presented a relationship type 'compartmentalized friendships', in which customers strengthen their own identity with the help of multiple brands, and not being restricted to one brand.

Brand love means that a customer has long-term fulfilled emotional attachment towards a brand (Carroll & Ahuvia 2006). This relationship is constructed around love, affection and passion (Khamitov et al. 2019), and it is achieved through satisfaction, self-brand connection and personal experiences (Rahman 2021). The relationship form of Fournier (1998) called 'committed partnerships' also reflects brand love, in which a committed customer is horrified of even thinking of an illicit affair with some other brand. In their study, Kim & Kwon (2011) used 'soulmates' as a metaphor for high-intensity relationships, following the description of 'committed partnerships' by Fournier (1998). However, Rossiter (2012) criticizes earlier brand love literature. He claims that responses of brand liking should not be confused with brand love, as has been erroneously done in some previous studies. In these, colloquial expressions (e.g., 'love') were mistakenly understood to represent real love instead of like.

Brand addiction is the emotional dependence of a customer on a brand, and it goes beyond compulsive buying. In brand addiction, the brand gives pleasure to the compulsive urges, and the customer experiences various symptoms of dependence, if the customer is separated from the brand (Mrad 2018). A brand-addicted customer has a deep trust relationship with the brand, and the brand plays a critical role in the well-being of the customer's daily life (Fajer & Schouten 1995). The brand is also irreplaceable compared to other brands, and the customer is obsessed with the brand (Fournier 1998). The four customer-brand relationship types all have their own characteristics and manifestations, which are summarized in Table 1.

Table 1: Summary of the characteristics of the relationship types

Strength	Relationship type	Characteristics
Weak	**Brand liking** (Fajer & Schouten 1995) (Casual friends/buddies; Fournier, 1998; Kim & Kwon 2011)	Fajer & Schouten (1995) - low commitment, easy substitution, liking the brand Fournier (1998) - lack of affectivity and engagement - few expectations on reciprocity - brand considered as a friend
Moderate	**Brand attachment** (Park et al. 2010; Khamitov et al. 2019) (Close friends; Fajer & Schouen 1995) (Compartmentalized friendships; Fournier 1998)	Park et al. (2010) - a bond between customer and brand - self-brand connection and prominence Khamitov et al. (2019) - intensive emotional captures, cognitive representation Fajer & Schouten (1995) - brand considered as good or close friend - no exclusive loyalty: multiple brands at the same time Fournier (1998) - identity strengthening through brand usage - multiple brands
Strong	**Brand love** (Carroll & Ahuvia 2016; Khamitov et al. 2019; Rahman et al. 2021) (Committed partnerships; Fournier	Carroll & Ahuvia (2006) - long-term relationship & fulfilled emotional attachment Khamitov et al. (2019) - love, affection, and passion Rahman et al. (2021)

	1998) (Soulmates; Kim & Kwon 2011)	- satisfaction, self-brand identification, personal experiences Fournier (1998) - horrified at illicit affairs
Very strong	**Brand addiction** (Fajer & Schouten 1995; Mrad 2018) (Dependencies; Fournier 1998)	Mrad (2018) - emotions, dependence - a pleasure to compulsive urges & addiction symptoms Fajer & Schouten (1995) - deep trust, a critical role in everyday life well-being Fournier (1998) - irreplaceability, obsession

3 Data collection and analysis

As the aim was to understand the relationship between digital brands and customers, a qualitative research approach was chosen for this study. We targeted active users of digital brands with several years of experience, and thus interviewed young Finnish adults aged 22 to 31. The data collection was conducted with individual semi-structured interviews in 2021. Following Fusch and Ness (2015) instruction on determining the number of the interviews by saturation, we continued interviews as long as no new relevant information could be obtained. As a result, fourteen people, seven males and seven females, were interviewed, and these are referred to as participants P1-P14 of this study (for details, see Appendix 1). Thirteen interviews were conducted via the Zoom online video conferencing software and one interview took place face-to-face. The average duration of the interviews was 41 minutes. The citations in the next chapter are translated from Finnish to English.

The interviewees were asked to talk about their use of those digital brands which they perceive important. No specific brands or brand-relationship types were mentioned by the interviewer. The discussed themes included: How participants perceive themselves as a user of the brand, the digital brand usage habits, pricing and value of usage, and emotional aspects of digital brand usage. The semi-structured manner provided an opportunity to discuss the topic more freely and, for example, add additional questions (Myers & Newman 2007). The interviews were all

recorded and transcribed, as recommended by Myers & Newman (2007). In the analysis, the transcribed and coded data was analyzed iteratively. The data was first coded based on the customer-brand relationship types identified from the literature. All expressions in which participants described their brand relationships were extracted from the material and placed under the most appropriate relationship type. Based on these expressions, the main themes describing the different customer-brand relationship types were then identified after multiple rounds of analysis. Thus, the relationship types were created through analyzing the interviewees' responses. The found relationship types are discussed next.

4 Findings: digital customer-brand relationships

Our findings show that all four customer-brand relationship types identified from the literature appear also in the context of digital brands. Manifestations of the relationship types are discussed below in more detail.

4.1 Brand liking

Brand liking appeared in the responses as lack of emotions, low commitment, and high expectations. Digital brands were used for communication, entertainment, and problem-solving. The interviewees described their most important brands using positively mild expressions such as 'nice', and without emotional aspects. The participants' commitment to the brand was rather mild. For example, naming a favorite brand was difficult for some participants, which represented a weak strength relationship between the brand and the interviewee.

> "I don't know which one is my favorite, maybe it could be WhatsApp. […] They are just nice services to have access to, better to have them than not to have them." – Male, 28 (P14)

The interviewees were willing to spend a reasonable amount of money on using digital brands, but only if these provided some entertainment, such as movies for the evening or solved some of their problems, including communicating with friends. Some participants valued great a 'price-quality ratio' or 'net benefit'. Brands were found extremely easy to be replaced, as the participants emphasized the ease of substitution.

> "I would immediately take another service. It's just an application […] You can find a similar service elsewhere." – Male, 25 (P7)

4.2 Brand attachment

Brand attachment was reflected in a bond between the interviewee and a brand. Digital brands were used, for example, for communication, entertainment, as a part of daily routine, and as a storage for one's digital content, such as photos or music. The interviewees described their most important brands with positive expressions such as 'important', 'safe' and 'favorite', but without using clear emotional words. For example, attachment was described by the words 'I'm attached', but without any stronger affection related expressions. Brand attachment was also explained by a participant's historical connection to a brand.

> "Well, maybe of some sort of [attachment]. I have had a social media account since 2010 with old pictures […] it's a photo album of my youth and my history." – Female, 29 (P2)

The participants described brands to be replaceable with small effort, and a substitute was easy to be imagined. However, removal of personally created content was considered inconvenient and thus created a threshold to change to another brand. Accepted brands were also characterized by familiarity and easiness to use.

> "Picky. That may be the correct word. I don't like to own multiple services. If I find a good service, I favor that one. I won't go looking for [similar] services. […] It's just a service, and I pay to get service features, but I don't have any emotional bond." – Male, 25 (P9)

4.3 Brand love

Brand love emerged as an emotional bond between a participant and a brand. The digital brands that were loved were used as an important part of daily routines, entertainment, communication, content creation, and information seeking. Brand love was expressed by strong emotional words such as 'I can't live without it', 'it has a big role in my life' or, 'very important part of my life'. However, the interviewees did not mention the word 'love' but described their attachment to brands directly, as 'pretty committed, active relationship'. Digital brands were even given human representations by, for example, equaling a digital brand relationship with brotherhood.

> "YouTube is [important] because if you can't do something then it will help. It is like a big brother from who one can always ask how this or that could be done, and it will help." – Male, 22 (P1)

Brand lovers also expressed their willingness to long-term commitment with their beloved brand. For example, the development of a currently used brands' services increased engagement and prevented a participant from changing from one brand to another. This brand relationship was not broken, even if similar brands would have had favorable new features. Brand lovers considered the replacement of the brand painful but possible.

> "I'm not resisting change, but I'm such a committed user of Spotify or Instagram that even if you would provide me a new competing and, very similar service, I would still have a big threshold to switch." – Female, 31 (P13)

> "It [the end of service] would annoy me a lot, but they are not irreplaceable. […] It has become such an entrenched habit that one opens Instagram and browses what has happened and so on. So yes, it would be annoying, but it would not be the end of the world" – Female, 26 (P3)

4.4 Brand addiction

In brand addiction, a digital brand is considered critically important in everyday life. The services provided by digital brands were used as a critical part of daily routines, entertainment, communication, content creation, and information search. The brand-addicted participants usually admitted their addiction, but, however, some also denied it. Brand addiction was expressed, for example, by describing addictive symptoms, which emerged if the usage of the brand was not possible. The service or application of a digital brand could be deleted from the device for a couple of hours, but then it was immediately downloaded back again. Expressions revealing addictive symptoms of the participants were, for example, 'nervousness', 'first thought in the morning', and 'loss of concentration'.

> "Well, I could say that I'm [addicted] to at least Netflix and if someone took Netflix away from me, yes, I'd try to replace that evening routine [watching Netflix] with something else. […] It is a kind of a symptom of addiction when you can't give up on unnecessary need. […] The same goes with music. I would get withdrawal symptoms at work, and my concentration would be disrupted, the pace of work would deteriorate, and my mood would be poor. […] But one can't consider this as a harmful addiction, like coffee, no one has yet died because of drinking coffee." – Male, 31 (P8)

> "[It is] an addiction. I feel that way. I'm not saying it's problematic, but it's a big part of life. When I wake up in the morning, I first check my messages, I check Instagram, everything" – Female, 26 (P6)

Strong trust toward the brand was a typical embodiment of brand addiction. It, for example, led to forgiveness in problematic situations. Furthermore, some were not even aware of the prices of the services they used, but they were mainly willing to pay for the services they trusted. The importance of a digital brand for a participant was described also as 'unconditional love', 'significant role in daily life', 'irreplaceable' and 'intimate relationship'.

> "I don't even know any other [brands] than Spotify. It's the only option I see to be able to fulfill my needs in my daily life in different situations. It's accompanying me." – Male, 24 (P10)

Brand addicted participants could also consider brand replacement as impossible. For example, co-created memories and superiority over other brands caused that no substitutes for the brand were not considered possible.

> "Netflix and Spotify, I have long history with those. They know my usage history from so many years, especially Spotify. […] Sometimes it suggests 'Hey, you listened this in the summer 2005' […] [Those] have so much valuable good data with memories to throw me back into these powerful emotional experiences." – Male, 31 (P8)

Despite of being aware of an addiction, brand addiction was not perceived as harmful by the participants. Instead, for the brand addicted, digital brands' services 'provided pleasure' and 'improved state of mind'.

5 Summary of the findings and concluding remarks

This study investigated relationships between customers and digital brands. The findings depict the four different relationship types and how they appear among the interviewed young Finnish adults. Table 2 below lists the findings of this study similar to previous research (reported in detail in Section 2), and summarizes the novel findings of this study.

Table 2: The characteristics of the relationships between customers and digital brands

Type	Findings similar with previous research	Novel findings of this study
Brand liking	- the brand is very easily replaced (Fajer & Schouten 1995) - low commitment (Fajer & Schouten 1995) - very low affectivity (Fournier 1998)	- low or reasonable investments, such as time or paying for a brand - high expectations for the brand - mild positive descriptions of brands
Brand attachment	- a bond between customer and brand with loyalty (Park et al. 2010) - no exclusive loyalty (Fajer & Schouten 1995) - multiple brands at the same time (Fournier 1998; Fajer & Schouten 1995) - brand connection (Jatpura et al. 2014)	- the brand is replaceable with small effort - positive descriptions of brands with little affective expressions - low affectivity - attachment concerns history
Brand love	- the brand is replaceable with inconveniences and 'illicit affairs' are avoided (Fournier 1998) - strong long-term emotional attachment relationship (Carroll & Ahuvia 2006) - affection (Khamitov et al. 2019) - satisfaction (Rahman et al. 2021)	- the brand is important part of daily routines - affective descriptions, even with human representations
Brand addiction	- the brand is irreplaceable (Fournier 1998) - strong affective commitment and attachment (Mrad 2018) - dependence (Fournier 1998; Mrad 2018) - a pleasure to compulsive urges (Mrad 2018) - addiction symptoms (Mrad 2018) - criticality in everyday life (Fajer & Schouten 1995)	- descriptions with affectivity, intense expressions, human representations, or forbidding - addiction was not perceived as harmful - no price sensitivity, not even knowing prices - daily life improvement due to the brand

As can be seen from Table 2, the results on the *brand liking* relationship type are partly in line with previous research. Low commitment a brand (Fajer & Schouten 1995) is presented in the results in the form of 'easy replacement'. The participant's expressions regarding digital brands emerged mild and positive, having thus similarities with the 'casual friend' category described by Fournier (1998), and '*brand liking*' reported by Fajer & Schouten (1995). Also, in line with previous studies of

Fajer & Schouten (1995) and Fournier (1998), an emotional aspect was noted to be low or lacking. On the other hand, the findings of this study diverged from previous research in the characteristics 'high expectations to brands' and 'possibilities to invest time and money'. The results of this research support Rossiter's (2012) criticism on interpreting emotional expressions too strongly, which leads to misunderstanding.

The findings on the *brand attachment* relationship type show brand bonding (Park et al. 2010) and brand connection (Jatpura et al. 2014). Despite this, affectivity and emotions were not as strong as described by Khamitov et al. (2019) and Jatpura et al. (2014), and further, a self-brand connection noted by Park et al. (2010) did not appear at all in the results. However, the manifestations in the brand attachment type are clearly stronger if compared to the manifestations of brand liking type, and there evidently exists clear favoring of an attached brand. The loyalty towards a brand was found to be stronger than in the corresponding categories by Fajer and Schouten (1995) and Fournier (1998). The results also indicated some attachment to a brand, but it could be changed with minor inconvenience, if it wasn't pleasing anymore.

The results of *brand love* typology were mainly in the line with the results of previous studies. For example, long-term emotional attachment (Carroll & Ahuvia 2006), commitment to one brand (Fournier 1998), satisfaction to services (Rahman et al. 2021), and passion (Khamitov et al. 2019), are presented within the expressions of the participants. Examples of such expressions include substitution reluctance, and these differed from the brand addiction type by including a possibility for brand replacement. Additionally, the participants did not literally indicate 'love' but a love-like affection such as in the 'big brother' metaphor.

Also, the findings of the *brand addiction* typology are in line with previous research. For example, a dependence relationship, including addiction symptoms (Mrad 2018), criticality in daily life (Fajer & Schouten 1995), and irreplaceability (Fournier 1998), was indicated by the participants. In addition to supporting these findings of earlier studies, brand relationship was described as an addiction with symptoms, but however, not negatively. Instead, the addicted relationship to a brand was mentioned to have positive and critical effects on the participants' daily routines.

The findings of this study suggest that the four customer-brand relationship types - brand liking, brand attachment, brand love and brand attachment - can be identified within digital brands. Customers create similar relationships with all kinds of brands, including digital and physical brands. However, when compared to physical brands, digital brands are more easily integrated into all events in everyday life, for example through a mobile phone. The use of digital brands is not tied to time or place when the brand is used with portable devices. Digital brands bring valuable online content into physical everyday life events, and thus unite the digital and physical worlds of the customer. For example, the correct music list was experienced to improve effectivity during work by the *brand addicted*. In addition, these customer-brand relationships can evolve in a process-like manner (Fournier 1998). Thus, various customer engagement activities carried out by brand management could strengthen the relationship evolvement. These actions should always be adjusted to fit the relationship type. This could mean, for example, highlighting problem-solving and net profit to *brand likers*, or co-created emotional memories to *brand lovers*.

As this study is qualitative, the presented findings are descriptive. The findings are based on the observations of individual participants' experiences on the topic. Further, results are limited by the demographics of the data, as only 22-31-year-old young Finnish adults were interviewed. Hence, future studies should investigate the customer-brand relationships with other methods and customer segments. Studies could also focus on specific brands and their relationships. Furthermore, future studies could investigate intangible digital brands' links to the physical world – how online and offline contexts and channels merge in customers' world as stressed by Kemppainen et al. (2019). Also, as digital brands and customers always have an intermediary between them, such as a device, the intermediary's effect on digital customer-brand relationships is also a great research possibility for the future. Finally, to conclude, all the customer-brand relationship types, their characteristics, and manifestations should be further explored.

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Appendix 1: Details of the participants of the study

	Age	Gender	Status	Interview duration (min)
P1	22	Male	Student	42
P2	29	Female	Employee	38
P3	26	Female	Student	41
P4	30	Female	Student	52
P5	27	Female	Employee	51
P6	26	Female	Employee	40
P7	25	Male	Student	23
P8	31	Male	Employee	57
P9	25	Male	Student	34
P10	24	Male	Student	42
P11	23	Female	Employee	35
P12	26	Male	Entrepreneur	31
P13	31	Female	Student	37
P14	28	Male	Employee	53

HEALTH SELF-MANAGEMENT SUPPORT WITH MICROLEARNING TO IMPROVE HYPERTENSION

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Abstract High blood pressure is a leading cause of premature death. Healthy lifestyle choices (of diet, exercise, sleep and stress) could offer significant results. However, health literacy and -competence are lacking in most people, compared to best practice health choices, so there is room for improvement in creating hypertension self-management results. We tested an intensive two-week Self-Management Support (SMS) pilot, using daily feedback and microlearning cycles. Participants (n=8) reduced their blood pressure from 145/92 to 126/86 mmHg on average. User evaluation on effectiveness of the health support elements highlighted the importance of key SMS components like: information transfer, daily monitoring, enhancing problem solving/decision making, self-treatment using a tailored action plan, coping skills and ongoing follow-up with skilled coaches. Moreover, several aspects from microlearning, peer coaching, results-achievement and feeling better (=intrinsic motivation) were useful and hold promise for future intervention updates.

Keywords: self-management support, microlearning, peer coaching, eHealth, hypertension.

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1 Introduction

We all know that health plans and healthy New Year's resolutions are usually pushed to the background relatively fast. The book 'Will power' elegantly describes how other priorities in 'the rest of our lives' soon draw most of our time and attention away from our new health plans (Baumeister & Tierney, 2012). So how to create healthy behaviors then? One solution is to aim for health literacy and intrinsic motivation (e.g. feeling better when in healthy patterns than in unhealthy patterns) to create healthy patterns that are self-sustaining or even self-growing. For example: if someone really enjoys tennis games and joins a club to play regularly, this fosters both intrinsic motivation (=fun of playing) and competence growth (increasing skills, stamina etc via practicing and wanting to continue tennis).

By contrast, health advice in standard care for a person with hypertension is often somewhat simplistic when viewed from a learning/teaching perspective and it is slow in its feedback cycle: e.g. "Try exercising more and reducing salt, then come back in three months to check your blood pressure again." This contrasts strongly with the lessons from SMS (Self-Management Support) literature for the need of individualized learning support, plus regular monitoring and follow up coaching (Dineen-Griffin, 2019). Thus it may be not surprising that many people experience unsatisfactory and/or slow results, leading them and their doctors to conclude that healthy lifestyle doesn't help them enough.

Hence we developed an intervention to combine two opportunities: Firstly, multiple studies show that rapid and significant blood pressure improvements are possible with healthy lifestyle. So we aim to achieve rapid improvements with our participants, see hypothesis 1 below. Secondly, even 'experienced patients' often lack the health literacy and -skills to create the most effective and sustained health habits. This means there is a lot of room for improvement. So in order to foster rapid improvements in health self-management skills, our intervention aimed to combine high impact health behaviors with twice-daily blood pressure monitoring and daily learning/training cycles.

We describe the results and user evaluations from a feasibility pilot of a 2-weeks high impact SMS lifestyle intervention, using a daily learning- and results feedback cycle. Apart from testing feasibility, attractiveness and robustness of the intervention with

n=8 participants, we also wanted to qualitatively evaluate results on two underlying research hypotheses for our intervention design:

Hypothesis 1: Significant blood pressure improvements can be achieved within two weeks, which are meaningful enough for participants in order to support health competence training and daily microlearning.

Hypothesis 2: Using high frequency microlearning in a multicomponent SMS intervention format with daily coaching and feedback can foster health literacy, health competence and habit formation, besides supporting motivation and self-efficacy.

2 Theory and concepts

Regarding the ***biology and effectiveness*** of healthy lifestyle interventions for tackling hypertension, longstanding research lines exist: overall (Roberts & Barnard, 2005) and regarding powerful short term effects on hypertension, inflammation and endothelial health of for example antioxidant foods (Franzini, 2012), flaxseed (Rodriguez-Leyva, 2013), beetroot and nitrates (Kapil, 2015), salt reduction (Dickinson, 2014) and healthy, low-fat food choices (Siervo, 2015), combined with exercise (Greger & Stone, 2016). We translated these research findings into explicit advise/lifestyle options for our participants to ***generate short term, measurable improvements*** for their endothelial health and blood pressure. This aimed to help jumpstart their positive feedback and learning cycles.

Central to the findings in the field of health ***Self-Management Support (SMS)*** is the need to have ongoing, tailored training/teaching cycles with individuals in order to build up their competences for health self-management (Jonkman, 2016, Dineen-Griffin, 2019). On the one hand there are several elements for the overall setup and quality of support: an activated participant / patient, skilled health professionals /coaches, face-to-face and multicomponent interventions in order for participants to have rapport with the health professional(s) and build up commitment for multiple self-management and self-education efforts, as well as having multiple options to tailor the action plan to their own context and priorities (Simons, 2020a, 2021).

On the other hand, several general ***support process*** components (besides support for specific health behaviors: e.g. exercise, diet, sleep, smoking etc) have been identified which are conducive to competence building of participants (Jonkman, 2016, Dineen-Griffin, 2019). This set of SMS process components also forms the ***evaluation framework*** we used for evaluating this feasibility pilot:

1. **Monitoring** of symptoms (regular, active self-monitoring)
2. **Information** transfer (throughout the learning process)
3. **Competence** building, including:
   a. ***Problem solving***/decision making
   b. ***Plan making***: self-treatment through use of an action plan
   c. ***Coping management***: skills for handling challenges, frustrations etc
   d. ***Resource utilization***: incl. social context or medication management

Next, several ***microlearning*** insights and concepts are relevant to our objectives of increasing health behavior competence levels of participants. Especially since our study took place in a work context, with most participants having quite busy work lives, which creates a need for very efficient learning and rapid proof of effectiveness. "Business is about productivity, not learning. [..] Inserting learning interventions into a busy employee's schedule is a real challenge" (Emerson, 2018). Hence, supplying concise single-learning topics to fit in between tasks or when employees can spare 5 – 15 minutes helps. Giurgiu (2017) states that microlearning should focus on only what you need to know. And that it should fulfill the human craving for instant gratification: satisfying short term goals that support long term goals. Gabrielli et al (2017) stress the "contextual, lifelong learning process [where microlearning must] enable a conversation with the world and oneself". This conversation includes: reflection, experimentation and interpretation of results. Competence building is about embedded learning, where doing and achieving results are at least as important as learning (Emerson, 2018). Finally, few things support motivation and competence building as much as achieving results (Simons, 2010, 2014, 2015, Greger & Stone, 2016) In sections 4 and 5, user evaluation results and discussion, we will reflect on the added value of the various eHealth intervention components for microlearning competence building.

3 Method

This study is an example of ***design research*** for health SMS (different from design science), since design research is aimed at creating knowledge for solving domain specific problems. In designing our intervention we followed the design cycle phases of Verschuren & Hartog (2005) and in this paper we focus on phases '6. evaluation' and '1. first hunch'. Our 'first hunch' is expressed in the two research hypotheses in the introduction (in short: that rapid blood pressure improvements and high-frequency microlearning support health competence development). Regarding phase 6 'evaluation', there are two aspects in this ***feasibility*** pilot. On the one hand we evaluate the attractiveness, feasibility and robustness of the intervention. This includes answering research hypothesis 1 regarding the effectiveness and added value of aiming for short term blood pressure improvements. On the other hand, we conduct a ***user based design evaluation*** on the perceived usefulness of the various elements in our multicomponent intervention, for qualitative answers on research hypothesis 2.

The health SMS ***intervention*** format is an updated version of the format used in the first two weeks of the high intensity T2D (Type 2 Diabetes) intervention described elsewhere (Simons, 2016, 2022). The updates regard blood pressure specific updates, a healthy menu App, a two-week-focus for training health competence skills and a much lower time investment: this to increase efficiency and improved fit with busy work schedules of employees. Core components of the ***eHealth intervention*** are: low threshold *mail triggers twice a day* for *blood pressure monitoring*, individualized *feedback and daily coaching*, *group coaching* and education, daily *peer coaching*, a *menu support App*, a *portal* with personalised *progress*, *online content* and *eTools* for health, lifestyle and blood pressure, plus *specific blood pressure lifestyle quick wins* that participants could use to kickstart their improvements. Apart from the tools and contact instances used, an important contribution for the ***microlearning*** field is the explicit strategy throughout the intervention to create multiple moments daily for learning, experimentation and reflection, in order to stimulate daily competence building cycles. There were on-site group sessions on Monday, Wednesday and Friday of week 1 (and digital group sessions on Tuesday and Thursday), plus on Friday of week 2, besides brief individual coach sessions per participant when needed, as a form of stepped care. Two coaches supported the group. For reasons of practicality, the intervention (and official blood pressure progress monitoring)

started on Monday morning of week 1 and finished at Friday morning of week 2, both moments combined with a group coaching and education session.

Study ***participants*** were university employees who volunteered for participating in the intervention, starting half-way November 2021 (n=8). All of them provided written consent for inclusion in these (anonimized) study results. Most of them (n=7) had participated in a more general employee health support program (Simons, 2017) somewhere in the 11 years before this intervention. Inclusion criteria for participation in this 2-weeks intensive blood pressure intervention were: commitment to making lifestyle changes and participating in the various coaching and support formats, plus having hypertension stage 1 or 2, hence systolic pressure between 130 – 179 or diastolic pressure between 80 – 119. Participants were asked to start measuring their blood pressure twice a day, three or four days before start of the intervention, logging the results in their dashboard via our email prompts. It turned out that one of the participants had slightly lower blood pressure at start than he thought, having 'heightened' levels in 5 of the 8 and 'hypertensive' levels in 3 of the 8 measurement moments before start, according to AHA norms (Whelton & Carey, 2017). The other participants consistently had hypertensive values before intervention start. After 2 weeks and 10 weeks group session user evaluations took place to collect feedback. Since the intention was to create health competences during the two weeks that would also have longer lasting value, survey-based individual feedback on intervention attractiveness and perceived usefulness of the intervention's components was collected at 10 weeks follow up, the results of which are reported below.

4 Results

There are two types of results confirming ***Hypothesis 1*** ('Significant blood pressure improvements can be achieved within two weeks, which are meaningful enough for participants in order to support health competence training and daily microlearning'). Firstly, Figure 1 illustrates that average blood pressure improved from 145/92 mmHg at start to 126/86 mmHg on Friday morning, eleven days later. Thus, diastolic pressure improved 7% and systolic pressure improved 13%, on top of the fact that one participant discontinued medication after week 1, following consultation with her physician. The overall improvement trend was visible across all participants, even the one participant who was not consistently hypertensive at

start, making the results relatively robust. Overall (though this cannot be statistically verified due to small sample size) the general research finding that larger lifestyle improvements lead to larger health improvements (Greger & Stone, 2016) was also visible as a trend in this group.

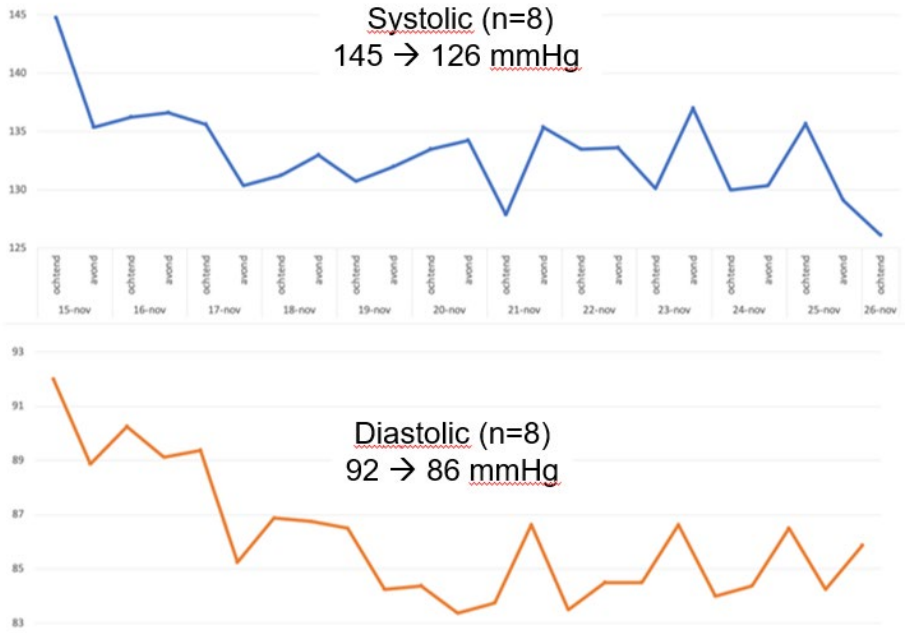


Figure 1: Average blood pressure improvement (n=8)

Secondly, most participants made explicit remarks during the group sessions on the direct effects they noticed between their health behaviors and their blood pressure. For example: working late, poor sleep, various dietary choices, exercise benefits, explicit relaxing vs. continued work day stress. Thus there was a double effect regarding meaningful feedback from blood pressure monitoring: individual lessons learned, but also sharing experiences in the group, which helped educate and motivate participants, even on days that they themselves did not have improved measurements.

Next, user evaluations showed qualitative confirmation for ***Hypothesis 2*** ('Using a microlearning approach in a multicomponent SMS intervention format with daily coaching and feedback can foster health literacy, health competence and habit formation, besides supporting motivation and self-efficacy'). We discuss two forms of user feedback. Firstly, Table 1 shows user evaluations on the perceived usefulness of the intervention components for supporting healthier behaviors. To guide interpretation, we clustered the components according to the SMS process framework, even though some components support more than one SMS process, as we will describe below Table 1. Scores were given on a 7-point Likert scale, ranging from 'totally disagree' to 'totally agree', in answer to the question: 'Which components stimulated you to adopt healthier behaviors?'

Table 1: Components that stimulated healthier behaviors (7-point (dis)agree, n=7/8[1])

Monitoring:	**Avg Score**
1. Mail triggers for blood pressure logging	4.9
2. Daily management	5.4
3. Gaining more blood pressure control	6.3
Information transfer:	
4. Start workshop	6.4
5. Healthy menu suggestions in the food App	4.4
6. Health and blood pressure information in portal	5.4
7. More understanding of blood pressure & health	6.1
Competence building:	
8. Follow-up workshops	6.3
9. Individual tips and answers to my questions from the coaches	6.6
10. Doing this as a group	6.4
11. Tips in dealing with challenges	6.0

In Table 1 we can see that the main perceived benefit from *Monitoring* was the amount of blood pressure control participants gained (3.), which is confirmed by the user explanations from Table 3 below. Regarding the second SMS process element, *Information transfer*, Table 1 indicates that the start workshop (4.) and increased understanding of blood pressure and health (7.) were valued most. These two

[1] One of the participants had an outlier pattern of scoring (since she could not be present at several of the group coach sessions, due to illness plus family logistics). Table 1 displays the average scores of the other 7. (Score 4=neutral) Her scores were resp.: 6; 6; 6/3; 3; 4; 5/3; 6; 3; 3. For n=8, the avg scores were resp.: 5.0; 5.5; 6.3/6.0; 4.3; 5.3; 6.0/5.9; 6.5; 6.0; 5.6.

intervention components (4. & 7.) were not just about information transfer, but also about increasing competences regarding: effective plan making and prioritizing efforts on those lifestyle choices that have the best combination of short term effectiveness and long term perceived attractiveness/ feasibility for a participant. The third SMS process element, *Competence building*, is key for training sustainable self-management skills and behaviors, especially since daily life provides several challenges to healthy behavior, as also listed in Table 2. All four components (8. to 11.) scored at least 6 out of 7 on average, so support for competence building was generally valued by the participants.

Table 2: Challenges to adopting healthy behaviors (participant group inputs)

Challenges:
1. Dealing with social events (and pressures towards unhealthy foods/drinks).
2. Involving family members, who are often attached to old patterns. Family dinner food dilemma's/choices which they may not follow.
3. How to stay on course? (What helped us: tips & tricks, peer support group, putting things in perspective.)
4. The first week's effects are easy; achieving the same degree of progress (and thus motivation) the second week is harder.

Table 2 lists some of the main challenges of participants in adopting healthier behavior patterns. These inputs were given during in response to the question: 'Which things did you find challenging in adopting healthy behaviors?' In Table 3 we list participant group inputs (by the end of week 2 and week 10) on the question: 'What helped you to achieve healthy behaviors?'

In short, participant feedback highlighted the importance of not only monitoring and information, but also the diversity and complexity in developing and practicing the wide range of competences involved in making multiple daily 'blood-pressure-healthy' behavior choices. Participants gave various examples of the forms of competence support also present in the SMS framework: decisions/problems solving, plan making, coping management and resource utilization. As elaborated in the discussion section below, the daily competence building moments strongly depended on the full breadth of the eHealth intervention mix.

Table 3: What helped to achieve healthy behaviors (participant group inputs)

What helped:
1. **Rapid feedback** from twice daily monitoring: see direct effects from behaviors.
2. Achieving **results** and enhancing **self-efficacy**: confirming you are on the right track. And the belief you can do this. Week 10: The power of experiencing that it really works. And confirmation that you can do this.
3. **'Quick results'-tips** (like using flax seed, beet juice and daily physical activity): to kick-start rapid results fast.
4. **Education**: which behaviors give the **largest results**.
5. **Practical tips for every-day choices and practicing new behavior patterns** (diet, exercise, sleep, alcohol, stress etc), including clever strategies and products in the supermarket. Week 10: All those practical tips to make things easier: for example healthy pizza base and toppings we can find in the supermarket.
6. **High quality coaches and coach sessions** (individual and group) **to increase mastery and health competences**: for questions, practical tips, deeper knowledge, reducing noise/confusion.
7. Helps to be in a **group with peer support**: for inspiration, peer coaching, practical tips and commitment/motivation, stimulating and teaching each other.
8. Education & peer coaching on **coping**: how to deal with various challenges (involving/coping with family and social context; low-salt or low-cheese; fast & healthy meals; time and tips for exercise and moderate level physical activity.)
9. Week 10: Building **healthy** '**new normal' patterns**: Easily replaced breakfast and lunch with healthier options. Or: Many 'heart-healthy' foods are now standard stock in our cooking. Or: Gotten used to new tastes (e.g. no cravings for sugar or salt). Or: Step counter as a tool for triggering regular activity. Or: Seeing the effects of stress on hypertension: impetus for better stress management habits.
10. Week 10: Power of **repetition and follow up**: some 'familiar health advice and resources' much more intensively internalized and used, in the past 10 weeks.

At the end of week 10 we asked three satisfaction questions (range 1 to 10), looking back at: the support received (score: 8.6), their health behavior progress after 2 weeks (score: 7.7) and evaluating their remaining health behaviors after 10 weeks (score 7.4)[2]. ***Two elements stand out in their feedback***, which extend beyond standard SMS literature. Firstly, the ***large added value of the group process***: not just for motivational reasons, but also for daily peer coaching, inspiration and practical tips.

[2] For n=7 participants. If we include the 8th participant who missed part of the sessions, see footnote 1, the scores were 8.4, 7.6 and 7.2 respectively.

Secondly, ***how baffling and inspiring it is to see how much blood pressure improvement can be achieved within 11 days:*** "By experiencing how well this works, I built up a strong belief in what else I could achieve after those first two weeks."

5 Discussion and contribution

This feasibility study has several ***limitations***. Firstly, due to its small scale (n=8) our two hypotheses are only qualitatively confirmed, not quantitatively. Secondly, our group of participants was not homogenous, nor was their use of all our support components. (On the upside, robustness of the intervention is thus tentatively confirmed, given that all participant blood pressures trended towards improvement, despite the heterogeneity.) Thirdly, the study tested multiple intervention components together, without control group, so interpretations of effectiveness and added value are of an (inter-)subjective nature.

Still, given the extensive qualitative inputs from this feasibility study, we tentatively propose some ***contributions to theory***. Firstly, whereas Self-Management Support theory mostly aims at managing diseases, symptoms, medication and on preventing disease progression towards worsening situations, we propose that focusing on *disease reversal* and on rapid, positive health results creates added value: not just for motivation and feeling better, but also for health literacy and -competence building. As one participant said: *"I now understand better how blood pressure improvement also represents healthier arteries and health overall."* Secondly, the difference between learning and competence building became quite apparent in this study: *doing and experimenting* rather than (cognitive) learning. One of the big challenges in the busy lives of the participants was to create enough time and focus for this. Three participants indicated that they had not been able to implement/attempt all the lessons they learned, even thought the concise, high-frequency microlearning approach in two weeks helped their learning focus. Some longer, 'deep dive' training formats were suggested: *"It is hard to implement all the useful tips. For example a supermarket safari for showing healthy choices would help my shopping choices further."* Thirdly, SMS and microlearning theory mostly focus on managing an individual's learning process. However, the power of *group support* we observed goes beyond motivational, affective or supportive (Simons, 2018, 2019, 2020b) aspects. Building on *Social Cognitive Learning* theory: competence building is enhanced by seeing, discussing and reflecting

on results of others and their experiments. In their words: *"By doing this together, I get much further. I learn a lot from the others' examples, suggestions and discussions."*

It may be easy to overlook the role of technology in this intervention, but ***technology was integral*** to many of its components, even beyond the eHealth/mHealth opportunity outlook given a decade ago (Simons & Hampe, 2010): daily home monitoring is now feasible thanks to affordable and reliable blood pressure consumer electronics; our mail/web-based coaching portal enables real-time progress tracking by participants and coaches alike; MS Teams meetings enabled daily high quality group and individual coaching without travel- or time constraints; our portal content database supports participants with multiple lessons on blood pressure and healthy lifestyle; the healthy menu App offered even included a button to directly order/deliver the ingredients to participants' homes (even though this latter option was not used). All in all, the multiple competence building lessons each day, which were the backbone of this intervention, were largely dependent on these technologies and tools.

To conclude, this intervention was attractive and feasible for the participants, as well as effective for achieving blood pressure improvements within 11 days, most notably an average drop in systolic pressure from 145 to 126 mmHg. The intervention offered many options for tailored information transfer, monitoring, coaching and competence building in the Self-Management Support (SMS) framework. On top of that, it illustrated the added value of: (a) group/peer coaching; (b) self-efficacy boosts by using 'quick-win options' and achieving relatively large health results within several days; (c) multiple (technology-enabled) health competence building lessons each day. These options hold promise for future health Self-Management Support innovations.

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How Consumers Progress to More Advanced Levels of Data-based Products and Services: A Scenario-Based Approach

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Abstract Data-based products and services (DBPS) utilise personal data to enhance their capabilities and provide consumers with a more intelligent and personalized experience. As a result, the experience of DBPS is fluid – the amount of data consumers feed into the product determines their experience. However, barriers such as privacy concerns hinder the progression to a more pronounced level at different thresholds. We developed and employed a scenario-based prospective incident technique to analyse how consumers experience DBPS at certain levels and how they advance from one level to another. Results show that consumers are willing to share non-critical personal data in exchange for mainly utilitarian benefits at basic DBPS levels. As DBPS usage progresses, consumers constantly perform cost-benefit assessments. Providers of DBPS can target these assessments by clearly communicating incremental added value to enable a small-step progression at all levels of usage.

Keywords: data-based products and services, customer experience, fluidity, triggers, barriers.

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1 Introduction

Today's products and services increasingly leverage data to improve the customer experience. This has been realised by advancements in technology for data capture, transmission, storage, processing, and analysis. Hoyer et al. (2020) state that "radically new technologies and associated software and hardware can transform the customer experience" (p. 58). The increasing reliance of products and services on technology and data makes them "fluid" artefacts that can evolve in terms of their capabilities and the value that is co-created by consumers, firms, and other players in the respective digital ecosystems (Raff, Wentzel, & Obwegeser, 2020; Ramaswamy & Ozcan, 2018). As a result, data-based products and services (DBPS) "fluidly" allow the co-creation of different levels of customer value in return for additional individual data. However, taking full advantage of this potential is all but trivial. In its most recent research priorities report, the Marketing Science Institute (2020) highlights that "[t]echnology offers customers an array of new ways to interact with firms, fundamentally altering the purchase experience and raising concerns about data privacy" (p. 5). The more data is required to create value for the customer (e.g., through personalization), the more a firm is dependent on the customer's willingness to share or give access to the required data. If customers are reluctant to do so, it is more difficult to provide them with the full features and capabilities of the product. Therefore, resolving this personalization-privacy paradox (PPP) is especially crucial for DBPS and challenges researchers and practitioners alike (Aguirre, Roggeveen, Grewal, & Wetzels, 2016; Marketing Science Institute, 2020; Puntoni, Reczek, Giesler, & Botti, 2021). This paper is among the first to address the lack of research on "fluid" DBPS (Hoyer et al., 2020) by explicitly exploring what drives and what inhibits consumers to engage with different levels of DBPS capabilities. The results help companies understand and support the customer progression from lower to more advanced levels of DBPS usage.

2 Literature Review

Data is a cornerstone of digital marketing. With continuous advances in technology, data increasingly permeates previously "dumb" physical products and environments, promising to make them "intelligent" or smart. The use of data in products and services can vary, ranging from simple digitization to more sophisticated use of artificial intelligence (AI), as the classification of smart products by Raff et al. (2020)

illustrates. Technologies powered by AI are considered to have the most significant effect on the customer experience (Hoyer et al., 2020), but with associated benefits for the consumer come potential costs that can inhibit the use of respective products and services (Puntoni et al., 2021). Raff et al. (2020) distinguish four archetypes of smart products: digital, connected, responsive, and intelligent products. All archetypes comprise physical (hardware) and virtual (software) elements that together allow for different levels of capabilities (Raff et al., 2020). More advanced archetypes add connectors, sensors, and actuators that are integrated with more complex software to achieve higher-level capabilities, such as sensing the environment and reacting to it.

Digital products combine basic hardware with basic operating software allowing for storing, processing, analysing, and transmitting data (Raff et al., 2020). *Connected* products can communicate and exchange information with other entities through various network technologies (e.g., Wi-Fi, Bluetooth, or RFID). By interacting and cooperating with other entities and devices, connected products can jointly create value by collaborating in assemblages (Raff et al., 2020). *Responsive* products, which add sensors and actuators, are never truly "finished" because they can acquire new capabilities through digital upgrades. This allows the co-creation of higher-level customer value through interactions (Raff et al., 2020; Ramaswamy & Ozcan, 2018). Examples of such products are rule-based smart-home actions or location-based services (Raff et al., 2020). Responsive products can easily evolve into *intelligent* products, the most advanced smart-product archetype (Raff et al., 2020). These products rely on AI that enables reasoning, decision making, autonomy, and proactivity – e.g., complex context-based services such as NEST Learning Thermostat or driverless vehicles as learning-based and self-organising autonomous systems (Raff et al., 2020).

Hoyer et al. (2020) expect that three specific technology clusters – all of them typically powered by AI – will most dramatically change the customer experience, namely (1) the Internet of Things (IoT); (2) augmented, virtual, and mixed reality (AR, VR, and MR); and (3) virtual assistants, chatbots, and robots. Such new technologies lead to the creation of new touchpoints and the reconfiguration of existing ones, and can create experiential value for consumers (Hoyer et al., 2020). Puntoni et al. (2021) also take an experiential perspective on consumer-facing AI-

enabled products and services but stress that while focusing on the benefits for the consumers, firms also need to pay attention to the costs consumers may encounter. Puntoni et al. (2021) distinguish four AI capabilities – namely listening, predicting, producing, and interacting – and four distinct consumer AI experiences that come along with each of these capabilities – namely data capture, classification, delegation, and social experience (Puntoni et al., 2021). In each of the experiences, consumers may encounter different benefits and costs. For example, consumers may experience data capture – i.e., different ways how AI systems collect data about consumers and their environments (AI listening capability) – as being served or being exploited (Puntoni et al., 2021). The perception of costs may prevent consumers from experiencing the benefits of AI-enabled products and services, resulting in dilemmas like the PPP (Puntoni et al., 2021). To effectively address such challenges, Puntoni et al. (2021) suggest that firms "could provide an initial basic service requiring limited disclosure of personal information and later offer the possibility to access an upgraded version that requires additional individual data" (p. 146). In this way, products, services, and respective touchpoints become increasingly "fluid" in terms of the information or data they require and the subsequent experiences they enable.

Hoyer et al. (2020) call for research on how new technologies transform the customer experience. Specifically for IoT, they suggest that future research should determine thresholds "beyond which consumer[s] perceive an invasion of privacy" (p. 66) and how such thresholds vary across contexts. Understanding such thresholds can be critical to the advancement of customers from a lower to a more sophisticated level of various "fluid" DBPS.

3 Research Methodology

We pursue a qualitative approach to explore how consumers respond to encounters with different levels of DBPS (De Keyser, Verleye, Lemon, Keiningham, & Klaus, 2020). We base our study on the critical incident technique (CIT; Bitner, Booms, & Tetreault, 1990; Gremler, 2004) and the sequential incident technique (SIT; Stauss & Weinlich, 1997). With CIT, consumers are typically asked to recall only critical service encounters. SIT also collects normal, uncritical incidents along a customer process (Jüttner, Schaffner, Windler, & Maklan, 2013). Both CIT and SIT are retrospective research methods (e.g., Gremler, 2004) where respondents tell about critical and uncritical incidents that have occurred in the past (Jüttner et al., 2013).

In our study, however, we inquire into a potential future instance, i.e., how consumers respond to possible incidents related to DBPS.

We developed *three scenarios* (De Keyser et al., 2020) of DBPS usage to operationalise this prospective perspective (see Table 1). Within these scenarios, we reproduced "fluidity" (Puntoni et al., 2021; Raff et al., 2020) by gradually increasing and manipulating the collection and usage of personal data leading to more DPBS capabilities and a more personalized experience. This method allows us to learn about how users would respond to different levels of DBPS usage. We termed our approach scenario-based prospective incident technique.

Table 1: Overview of situation and choice incidents by scenario and usage intensity level

Usage intensity	**Incident type**	**Scenario 1: IoT-based smart home solution**	**Scenario 2: Conversational user interface-based airplane ticketing**	**Scenario 3: App-based loyalty platform**
Level 1: Digital	Situation	Using smart home devices with an app	Chatbot-guided booking	Loyalty app
	Choice	Using a hub to interconnect devices	Creating a personal account	Creating a personal account
Level 2: Rule-based	Situation	Hub-based smart home incl. lights and heating	Rebooking push notifications based on account	Sharing loyalty points with friends
	Choice	Rule-based integration of front door lock into a hub	Adding passport and credit card to an account	Feeding app with personal data (location)
Level 3: Intelligent & Autonomous	Situation	Intelligent hub with personal recommendations (e.g., meals)	Voice-based intelligent assistant	Buying deals with credit card
	Choice	Autonomous decision-making by hub (e.g., purchases)	Self-learning voice assistant	Autonomous deal purchases by an app

All three scenarios were developed with industry partners operating in the airline, the consumer electronics, and the CRM industry. In each scenario, we designed *three levels of usage intensity* in terms of product capabilities and user interaction. The first level covers digital technologies (e.g., usage of an app instead of physical cards for loyalty programs). The second level adds rule-based functions (e.g., front door locked with smartwatch) or social aspects (e.g., exchanging loyalty points with friends). The third level then uses AI and service autonomy, describing systems able to take decisions and make intelligent suggestions on their own. In summary, level 1 describes the basic function of the DBPS and rather passive users, whereas towards level 3, users become co-creators of the DBPS by increasingly sharing more personal data (see Table 1). All levels were supplemented with a visual illustration so that interviewees could better immerse themselves in the described scenarios (see Stauss & Weinlich, 1997). Figure 1 exemplarily shows the examples for the scenario IoT-based smart home solution.

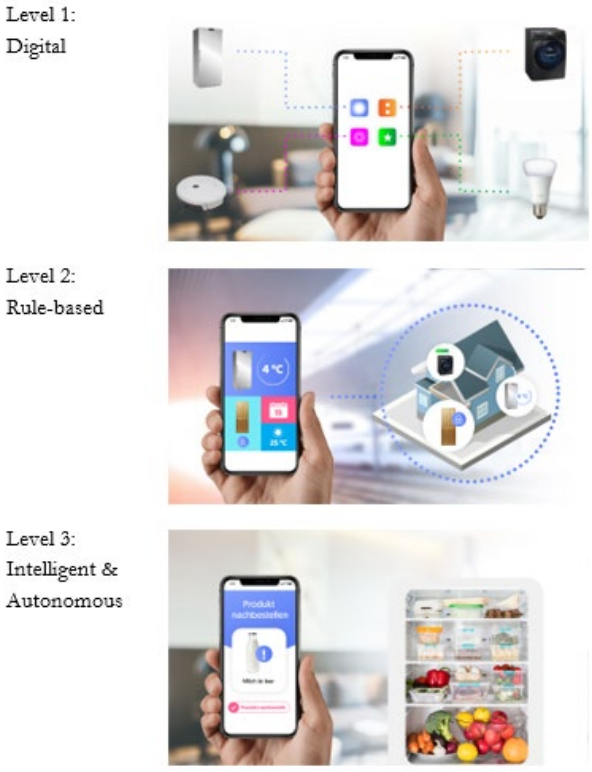


Figure 1: Visual illustration for IoT-based smart home solution used during interviews

Each level consisted of *two types of incidents*: First, a descriptive situation incident had to be evaluated (e.g., "imagine you're using a smart hoover …"). With the situation incidents, we aimed to assess attitudinal aspects related to DBPS. Secondly, a choice incident was examined to evaluate which factors drive or inhibit the intention to use DBPS (e.g., "what conditions would lead you to connect your smart devices in a hub?"). The distinction between choice and situation incidents allowed us to understand how consumers feel at different DBPS levels (situation) and how they advance from one level to another (choice).

After two pre-tests in September 2020, the interviews were conducted with Swiss consumers in October and November 2020. The industry partners and the authors jointly recruited the participants. The interviews were conducted online via Zoom and lasted 50 minutes on average. The sample (n=12) was balanced regarding age, gender, and tertiary education (mean age: 37.5 years, 50% female, 50% with tertiary education) and covered varying degrees of technology innovativeness (mean of 3.4 on a 5-point Likert scale with 5 representing the highest degree of innovativeness).[1] In each interview, the participant was guided through two scenarios. Per scenario, the interviewer described each of the six incidents which belonged to the scenario (two incidents per level, see Table 1) and asked corresponding questions. For each level, an illustration of the level was shown to the interviewee via screenshare in Zoom (see Figure 1, as example for scenario 1). To achieve an equal distribution across scenarios and balance out order effects, all six possibilities to combine any two of them were presented to the 12 interviewees. In sum, the 24 scenario evaluations lead to 144 evaluations of situations and choices.

All interviews were fully recorded and partially transcribed by the research team. Interviewers' standardised questions and conversation fragments unrelated to the scenarios or DBPS in general were omitted. The research team developed an initial code book based on literature (e.g., Hubert et al., 2019). Three authors individually coded one scenario using MAXQDA and added it to the code book. Finally, the individual code books and results were integrated and discussed by the whole research team (Spiggle, 1994).

[1] We measured technology innovativeness with a three-item scale adapted from Tussyadiah et al. (2015), Agarwal and Prasad (1998), and Goldsmith and Hofacker (1991).

4 Results

The findings of our study comprise general results that are agnostic to levels of usage intensity as well as results that are specific to the respective level of usage intensity.

4.1 Level-agnostic Results

We discussed different types of data that informants could decide to share or save in a profile throughout all three levels. Depending on the type of data, informants displayed varying willingness to share it. Email addresses and names are information most participants are willing to share or add to a profile. Several informants stated that they maintain several email addresses and may provide one that is only used when "spam" is expected. Informants, however, are less willing to share data like residential addresses, current location data, or health information (e.g., obtained by fitness trackers). However, they are willing to share such information, provided they get an adequate *added value* in return (e.g., getting more relevant information about their area when sharing their location) and can individually customise the type and extent of data shared (e.g., sharing location data for only a specified time frame). Informants were most reluctant to share or give access to conversational data (e.g., previous chat protocols) and payment information (e.g., credit card).

Informants repeatedly made cost-benefit assessments at all three levels. Limited benefits and highly perceived costs prevent the usage of DBPS. On the benefit side, informants often mentioned a lack of confidence in the *reliability of the technology*, partly based on previous experience with the respective technology cluster, e.g.: "[The difficulty is] to find one that works. I already talked with a robot on the phone. It was terrible.", informant #3. The perceived added value might not be sufficient even if reliability was given. For example, when more sensitive information like passport numbers could be added to a profile to save time with ulterior bookings, most people did not see this benefit as significant enough to share the information ("I don't book flights so often", #9). On the cost side, informants often mentioned privacy and security aspects. Informants were worried that companies would use their information for advertisements or sell them for profit, indicating *privacy concerns*. This seems to be an almost natural reaction: if people are requested to provide their email address, they consequently expect that it will be used in some way: "[…] in the future, data increasingly […] is seen as currency" (#9). In addition, *security concerns* can

outweigh potential utilitarian benefits (e.g., saving time) of providing sensitive personal data such as payment information. Multiple informants stated previous experiences with stolen credit card numbers ("A login can be hacked very easily, that's too insecure for me.", #8).

4.2 Level-specific Results

At level 1, most informants displayed a positive attitude towards the described encounters with technology for all scenarios. Mainly *utilitarian benefits* such as saving time, usefulness, convenience, or universal availability and access were mentioned and confirmed by the informants. Similarly, for all scenarios, most informants would decide to create an account or connect multiple smart-home appliances to a hub, again clearly driven by utilitarian benefits such as "one-stop-shopping" to control several devices from one place, saving effort or time, or convenience: "Have everything at hand within two seconds" (#3).

At level 2, all scenarios progressed towards more sophisticated use of technology, promising greater potential benefits for the user. Across all scenarios, at least half of the informants displayed a positive attitude towards the respective solution. Typical *utilitarian benefits* such as saving time, usefulness, and convenience were acknowledged in the IoT and chatbot/virtual assistant scenarios. In addition, half of the informants acknowledged *environmental benefits* in the IoT scenario ("When you are not at home, it does not have to be warm anyway", #11). In addition, *social benefits* can motivate DBPS usage: sharing or trading loyalty points with others would rather be pursued if one's peer group participates likewise, indicating the importance of direct and indirect network effects in such settings.

Greater integration of technology in the level-2 incidents triggered critical views on *technology dependence* ("[Because of] laziness or convenience, you will end up enslaved by a machine", #11) and a *perceived loss of control* in comparison to performing certain tasks physically or oneself ("If I do it myself and I'm feeling unsure, I recheck it [the front door], and then I'm assured.", #12).

At level 3, the scenarios further progressed towards more intelligence and autonomy of the technology. Most people did not like high degrees of autonomy: None of the

informants decided to let an AI make any purchases for them. Typical reasons were to *keep control and autonomy*. However, some informants stated that they would appreciate recommendations (e.g., helping with shopping lists) but that they want to retain control when it comes to actual decisions with real-life impact ("I would want to do and decide all this myself.", #11).

Informants remain critical of systems that learn via data they receive from consumer interactions (e.g., bots that learn from chat protocols). Either because the idea of an AI knowing too much about them was eerie ("I find it rather alienating that [a bot] recognises me and links me to an account.", #9) or because they felt observed by the company behind the technologies ("If they know what you enjoy, what you prefer to eat, how your voice sounds, that's total surveillance.", #1). Multiple informants stated uneasiness associated with the possibilities of intelligent systems ("It's alarming that machines are capable of doing so much already", #11).

Associated benefits with autonomous systems are typical *utilitarian* aspects and increased *sustainability*, for example, by providing ways to reduce food waste ("[…] a notification that something is expiring, and I should eat it [before it expires]", #10). A new motivation to use technologies at level 3 was curiosity and desire to try out new things ("I would give it a try to see if it really works, with those suggestions and everything.", #7).

5 Conclusion & Implications

Our study focused on customer interactions with different DBPS usage levels and, thus, reacted to research calls regarding customer experience associated with "fluid" smart products (Hoyer et al., 2020; Puntoni et al., 2021). The results revealed that consumers weigh potential costs against potential benefits when deciding whether to engage with DBPS. Such cost-benefit assessments occur at all investigated levels of "fluid" DPBS but can lead to different outcomes. Even at the most basic level, consumers raised concerns about privacy and security and saw a lack of confidence in the reliability of the technology. This is in line with the most relevant perceived disadvantage of smart products in Switzerland: they collect personal data (Zimmermann, Görgen, de Bellis, & Hofstetter, 2022). However, level 1 required only limited data from the consumers. Sharing or giving access to limited personal data keeps potential costs at a minimum. Thus, most utilitarian benefits outweigh

the potential costs. As the scenarios moved towards leveraging more personal data to generate a more personalized customer experience, potential costs associated with privacy or security concerns, and with unreliable technology gained more weight. These higher potential costs must be balanced by sufficiently high benefits so that consumers decide to advance to higher levels of "fluid" DBPS. Besides utilitarian aspects, such benefits can be of social (e.g., sharing an experience with the peer group), hedonic (e.g., receiving inspiration and trying out new things), and environmental (e.g., saving energy) nature, as indicated by our results.

The implications of our study are twofold: first, from a methodological perspective, we proposed the scenario-based prospective incident technique that allows the analysis of different levels of usage of DBPS and the customer progression between those. This is crucial for marketers and customers alike. Especially in European countries, companies encounter a high level of scepticism towards DBPS. This has a negative impact on market diffusion, on users' digital literacy and thus, on exploiting the full digitalisation potential. Secondly, from a managerial perspective, our results help companies understand and support the customers in their progression from lower to more advanced levels of DBPS usage. First and foremost, the individual perception of relevant benefits is the main motivator for DBPS adoption. It is thus paramount for companies to prominently communicate their DBPS benefits at all levels. Short texts close to input fields for user data may explain, briefly and focused, how the provided user information is stored and used and what customers get in return. To lower potential costs, companies could rely on certificates as indicators for data security and privacy. Big and established companies should ensure that DBPS are clearly linked to the company so that the (corporate) brand can promote trust in the technology. In addition, long and possibly complicated data protection declarations could be complemented by easy-to-understand visual pictograms. Since our results revealed that consumers are generally very willing to engage with basic-level DBPS, companies should offer basic versions requiring only little personal data that can evolve to a more advanced level later. Progression to more advanced usage levels should be possible in small steps, reducing the impact of new risks and requiring only a few cognitive resources from customers to update their cost-benefit assessment. Customers should be able to share their experiences and progression with peers so that groups can advance together.

Many avenues remain to be explored in future research. First, we did not consider product prices in our scenario descriptions. Prices should be integrated into the cost-benefit assessment in further studies. However, multiple informants stated that their adoption would also depend on market prices, which indicates that price considerations have not been completely ignored. Secondly, further studies should investigate how customer experience at different DBPS usage levels and the progression between those differ among various customer segments. It is likely that individual characteristics significantly determine the cost-benefit assessment and the experience at different levels. Finally, future research may deepen the interplay between different DBPS from an ecosystem perspective. Progression to a more pronounced level in one DBPS may propel progression in other DBPS as well.

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Reconciling the Debate on People Analytics in Academia and Practice

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Abstract People analytics depicts the algorithmization of human resources management characterized by the data-driven automation and support of people-related processes or tasks. On the one hand, people analytics promises productivity increases through optimizing workforce planning, hiring, or talent development. On the other hand, the extensive data collection and analysis of employees' behaviors can be perceived as invasive, raising privacy concerns. This debate cannot only be explained by diverging norms and values, for example, practitioners realizing commercial opportunities while being criticized by academic commentaries. Instead, an alternative explanation suggests that the opposing views can be reconciled by diving into the conceptual differences regarding what analytical methods and data sources people analytics entails. Hence, this paper proposes the conceptions of operational and strategic people analytics based on a literature review of academics' and practitioners' literature. Four propositions about these conceptions' privacy and performance implications are derived. Future research should empirically validate these propositions.

Keywords: people analytics, criticism, conceptions, strategy, operations.

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1 Introduction: The Hype around People Analytics

People analytics is a hype topic seeing rising attention in professional practice (Chen et al., 2018). Practitioners popularize the topic with increasing availability of tools and functionalities, for example, AI-based video assessments, or consultancies, such as IBM or McKinsey, selling evidence-based hypothetico-deductive analyses for the human resources function (Hüllmann et al., 2021). People analytics describes the algorithmization of decision-making in people-related organizational processes such as hiring, retention, or staffing. Technological advances, unprecedented data availability, and cultural changes that consider humans as "walking data generators" drive the topic (McAfee & Brynjolfsson, 2012). Understandably, people analytics sparks considerable controversy and is being discussed in mainstream media (Ajunwa, 2019) and academic outlets (Gal et al., 2017; Tursunbayeva et al., 2021).

Critics reject people analytics on the grounds of unethical surveillance and privacy invasion through fine-granular tracing of employee activity. They slander people analytics as reminiscent of the dystopian Taylorism (Hüllmann & Mattern, 2020). Others question the construct and external validity of people analytics' methods. They claim there is little empirical evidence for the promised outcomes (Marler & Boudreau, 2017). It is suggested that the employees affected by people analytics suffer negative consequences due to discrimination through the underlying algorithms and data sources, which reproduce existing stereotypes and biases (Gal et al., 2017). Further negative consequences of people analytics include stress due to a pressure to perform, resulting from the "transparent employee" (Hafermalz, 2021). Proponents of people analytics praise the data-driven and seemingly objective decisions that lead to more effective human resources management. Examples include improving retention rates and reducing employee attrition, stronger talent management, and lean human resources processes on the operational level (Marler & Boudreau, 2017). Levenson (2018) claims that people analytics supports strategy execution, resulting in competitive advantage through long-term workforce planning.

Are the reasons for these opposing viewpoints on people analytics simply a result of different values and norms, for example, the privacy invasion is acceptable if it leads to improved organizational outcomes? It is questionable that leading academic institutions such as Harvard Business Review would endorse such approaches

(Leonardi & Contractor, 2018; Levenson, 2018). Perhaps, the controversy can be explained by practitioners realizing commercial opportunities and selling ethically problematic information systems? Although some practitioners do this, certainly not all of them can be accused of this, for example, Microsoft and IBM are engaging in people analytics while conforming to their respective privacy legislations (Hüllmann et al., 2021).

This paper puts forward an alternative explanation. It suggests that this controversy can be explained partially by diverging conceptions regarding what analytical methods and data sources people analytics entails. Conceptions are the underlying implicit assumptions and mental representations that people have in mind for people analytics (Laurence & Margolis, 1999). For example, software vendors focus on automating single human resources tasks via artificial intelligence and other computational approaches based on individual employees' behavioral data. In contrast, consultancies concentrate on the abstract idea of data-driven human resources management, including strategic decision-making regarding the workforce based on aggregated data and hypotheses tests. So far, only broad conceptions of people analytics have been put forward that do not sufficiently demarcate these conceptual differences in detail. For example, Hüllmann and Mattern (2020) define people analytics as "*socio-technical systems and associated processes that enable data-driven (or algorithmic) decision-making to improve people-related organizational outcomes*." Such a broad definition cannot capture the necessary differences in data sources and analytical methods of people analytics that influence how experts perceive the topic. Hence, this paper asks the research question: ***How can the diverging conceptions of people analytics explain and reconcile the opposing viewpoints?***

This paper reconciles the controversy of people analytics by diving into the conceptual assumptions underlying the term, elaborating on what analytical methods and data sources are employed in practice. These assumptions are compared with the conceptions espoused by critical academic commentaries. Although the different conceptions cannot explain all of the controversy surrounding people analytics, the reconciliation contributes to structuring the debate. It bridges the gap between practitioners and academics, who drive the opposing viewpoints. This paper's contribution guides future research in deriving and testing more empirically valid constructs regarding people analytics. Its argumentation is based on an exhaustive review of academics' and practitioners' literature. The remainder of the manuscript

is organized as follows: section two introduces the core ideas behind people analytics, section three depicts the literature search and coding approach, and lastly, section four presents the findings and discusses the implications.

2 Background: Datafication of Human Resources

In the 21st century, discussions around big data and data-driven activities spawn in any business function. For people analytics, the nucleus is found in the human resources function, which progresses from basic controlling metrics and key performance indicators. It sees prospects in collecting and analyzing data about employees' behaviors to transform their decision-making from intuitive and experiential toward data-driven and evidence-based for informing traditional human resources processes (Marler & Boudreau, 2017). Although people analytics originated in human resources, the topic is relevant for any business function concerned with people management (Fecheyr-Lippens et al., 2015). The underlying premise is that data is objective and leads to better decisions than intuition, ultimately guiding organizations to achieve higher performance.

Predictive modeling that generates insights from descriptive and inferential statistical techniques is involved in people analytics. Information technology artifacts play a focal role. Compared to traditional human resource information systems (Dulebohn & Johnson, 2013; Ives et al., 1980), people analytics bears novel features that bring about altered organizational implications. So far, these implications are poorly understood because the underlying mental conceptions of people analytics vary considerably (Hüllmann & Mattern, 2020; Tursunbayeva et al., 2018). For example, Marler and Boudreau (2017, p. 15) define people analytics as a digital "human resources practice", whereas Cheng (2017, p. 2) understands it as a type of software tool. In contrast to this operational level of activity, Lawler and Boudreau (2015) consider people analytics a strategic approach with the means for strategic influence and guidance, delivering competitive advantage.

2.1 The Debate: Critics' and Proponents' Opposing Viewpoints

The variety in goals, analytical methods, and data sources is conducive to the contentious debate and controversy. Critics focus on people analytics as an exclusively quantitative approach using algorithms for analyzing big data, behavioral

data, and digital traces. This conception causes criticism because it entails collecting employees' behavioral data at a fine-granular level.

Big data is not neutral. The algorithms reproduce the bias and discrimination inherited from the historical data, as well as the design choices by the developers (Gal et al., 2020; Hüllmann et al., 2021; Tursunbayeva et al., 2021). For example, the Amazon hiring algorithm got scrapped because it discriminated against females (Dastin, 2018). The reduction of complex social phenomena to simple metrics can give a false sense of objectivity (Gal et al., 2017). Construct validity of instruments based on behavioral data should be ensured through independent scientific studies (Braun & Kuljanin, 2015). However, the algorithms are often proprietary and opaque. Thus, validity cannot be guaranteed, and affected employees are unable to evaluate the algorithm (Goad & Gal, 2018). At the same time, more transparency increases the risk of "gaming the metrics", further questioning the algorithms' validity (Hüllmann, 2019). Reducing people-related organizational outcomes to mere performance metrics that can be optimized disregards the humans' feelings, intentions, and context, leading to dehumanization of work (Riemer & Peter, 2020). Similarly, optimization through nudging and shaping human behaviors can be considered manipulation (Tursunbayeva et al., 2021). All these issues can result in discomfort and stress for the employees, counteracting any positive effects. Tursunbayeva et al. (2021) report that the collection of behavioral data may extend into the employees' personal lives, escalating the looming issues surrounding privacy invasion, surveillance, ethics and legal risks (Hüllmann et al., 2021).

Despite these issues, around 70% of large enterprises consider people analytics a high priority and report having a people analytics team (Hüllmann & Mattern, 2020). The proponents of people analytics argue that it is not exclusively about algorithms and AI-based automation of human resources tasks. It is not about surveilling individuals. Instead, they argue that people analytics is about the scientific approach of hypothetic-deductive inquiry and reasoning, that is, evidence-based optimization of people-related processes. It is about hypothesis testing and rigorous analyses on the team- and organizational-level based on high-level aggregated and anonymized behavioral data (Angrave et al., 2016; Huselid, 2018). Bias and discrimination are avoided by using empirically validated instruments (Huselid, 2018) or conducting qualitative research that does not suffer from statistical errors (Levenson, 2018; Simón & Ferreiro, 2018). This understanding of *aggregate* employee behavior implies that people analytics supports enhancing job performance through changes in work

design and organizational staffing (Levenson, 2018). It can help to scrutinize informal structures and relationships for improving engagement (Leonardi & Contractor, 2018), or alter human resources processes such as recruiting, training, and staffing, increasing effectiveness and efficiency (Marler & Boudreau, 2017; van den Heuvel & Bondarouk, 2017). Long-term optimization of people-related processes such as workforce planning, talent development, and staffing can achieve strategic competitive advantage (Huselid, 2018; Levenson, 2018).

Clashing norms and values can partially explain this controversy. Clearly, the AI-based tools that automate specific tasks of the human resources function based on an excessive collection of behavioral data do exist (Hüllmann et al., 2021). Practitioners follow commercial interests and deem such approaches viable, whereas critics complain about surveillance and privacy invasion (Hüllmann et al., 2021). Concomitantly, critics may reject people analytics, even if it is based on anonymized and highly-aggregated data on the grounds of dehumanization, little evidence for its positive effects, or risk of reidentification (Marler & Boudreau, 2017). However, the variety in values, norms, and ethics does not explain how high-level aggregated and anonymized data leads to extensive surveillance. It does not explain how interviews and qualitative inquiries can facilitate employee surveillance (Hafermalz, 2021). It does not consider that long-term optimization of human resources processes such as workforce allocation, development, or staffing is different from automating single human resources tasks through behavioral data collection and analysis, such as AI-based video assessments for selecting prospective recruits. These differences in conceptions lead to friction and fuel the controversy and debate. For the debate to be more productive, it needs to be more nuanced.

3 Methods: Reviewing Academia and Practice

This paper resolves the research question by providing an overview of people analytics, reviewing and organizing academics' and practitioners' literature on the topic. The years from 2014 to 2021 are included since the first hype started around 2014. Based on the results, a multidimensional categorization that captures the dominant variants of people analytics' conceptions among practitioners and academics is proposed. To identify relevant pieces of literature, academic databases and consultancy websites were searched by keywords, and additionally, the consultancy websites were searched by manual query. The keywords were selected

based on previous studies (Hüllmann & Mattern, 2020; Tursunbayeva et al., 2018). Synonyms such as "HR analytics" and "workforce analytics" were included. The keywords are illustrated in Figure 1 together with the overall search process that resulted in the body of literature of academics' and practitioners' manuscripts.

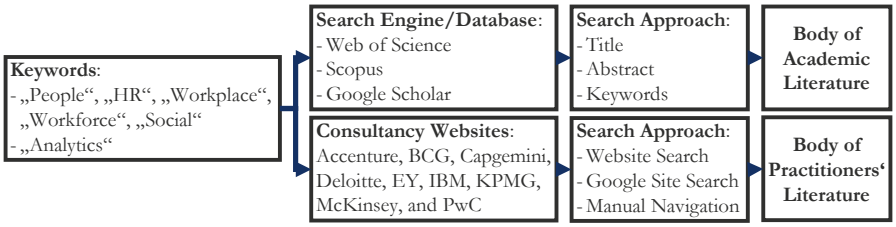


Figure 1: Search Process for Academic and Practitioners' Literature

For searching the academic literature, one search engine and two scientific databases were used to get an exhaustive overview, following established recommendations (vom Brocke et al., 2009; Webster & Watson, 2002). For querying the databases, the fields *title*, *abstract*, and *keywords* were used to balance precision and recall. The search query was constructed by concatenating each keyword with "Analytics" (Figure 1) and joining the concatenations by the "OR" operator. The "OR" operator was also used to account for common synonyms (e.g., "HR" OR "human resource[s]"). Because Google Scholar does not index the abstract or keywords, the results were filtered through the title field using advanced search and the parameter "allintitle:". To reduce the number of consultancies, the top 20 consultancies by revenue were identified (Gartner, 2018), expecting relevant input in terms of research and development on a novel topic such as people analytics. Preliminary screening to determine if the consultancies provide relevant input, services, or expertise on people analytics yielded the nine consultancies shown in Figure 1 (ordered alphabetically). To identify relevant information on the consultancies' websites, three different search approaches based on the keywords were applied (cf. Figure 1): **(1)** Use of the search function of the website; **(2)** Use of Google's site search function (e.g., site: http://example.com/ "HR "analytics"); **(3)** Manual navigation through the website.

Most consultancy websites do not have a search function, and Google search provides too many irrelevant results (similar to Google Scholar). Thus, the websites were manually navigated and scrutinized for relevant information based on the keywords. The search was conducted by the author and two research assistants. Since each consultancy named and positioned the relevant sections of their website differently, following hyperlinks was ad-hoc and based on intuition.

Table 1: Coding Scheme adapted from Hüllmann and Mattern (2020)

Dimension	Explanation
Information Technology	What is the role of information technology?
Data Sources	What data sources are collected and analyzed?
Methods	What are the methods being used?
Stakeholders	Who is responsible and drives the topic?
Scope	What is the scope of outcomes, goals, or purposes?
Unit of Analysis	Which unit of analysis is depicted?
Consequences	What are the consequences of applying people analytics?

The information gathered from the literature is analyzed using a coding scheme developed by Hüllmann & Mattern (2020), rooted in early information systems frameworks (Ives et al., 1980). The coding scheme breaks down the implicit assumptions and mental representations into smaller constituents, enabling demarcation of people analytics' conceptions in detail. From the coding scheme, the dimensions relevant to answering this paper's research question were selected (Table 1). The analysis is conducted through an explorative two-cycle coding approach (Saldana, 2009). During the first cycle, the author and two research assistants independently generated codes from the manuscripts, inductively, yielding a diverging set of codes. The codes differed in syntax (the words being used as the codes) and semantics (what was meant by the codes). During the second cycle, the same researchers jointly resolved all non-matching codes to agree on the final set of codes, from which the results are derived.

4 Findings: Operational versus Strategic People Analytics

The literature search yielded more than 100 papers after querying the databases by title, abstract, and keywords. After inspecting the full text and screening for relevance to the research question, 42 papers were included in the analysis. The

results show that there is unanimity in the fact that people analytics is a tool for supporting decision-making related to people outcomes in the organization. In the details, however, two overarching people analytics' conceptions based on the targeted level of managerial activity were identified (Anthony, 1965): **strategic** and **operational people analytics**. All dimensions were coded for practitioners and academics each, extracting and condensing the findings, which are summarized in Table 2. Operational people analytics emphasizes the digitalization of operational human resources processes through machine learning and information technology. It is perceived as the next incremental step to digitize human resources processes and practices by applying quantitative, data-driven methods. It focuses on human resources functions' core objectives, such as hiring, retention, staffing, and uses quantitative and data-driven approaches. Both academics and software vendors leverage this conception by focusing on tools that support or automate single human resources processes or tasks, for example, AI-based video assessments. Strategic people analytics turns away from perceiving people analytics as an operations supporting tool and advertises the "next evolution step for the human resources" function instead. It focuses on leveraging people analytics for strategic processes such as long-term workforce development and the firm's digital transformation. The main areas of application are workforce, talent, and leadership development and the strategic alignment of the human resources strategy with the overall business strategy. It subsumes qualitative and quantitative approaches. The insights are used for manual and semi-automated analyses to inform strategic planning processes. Following this conception, people analytics is not only a topic for middle management and human resources executives but branches out to the broader senior and c-level. Consultancies drive this conception, advertising high-level consultancy services and promising a strategic role for the human resources function.

Compared to traditional human resource information systems, both the operational and strategic people analytics' conceptions share novel characteristics in (1) unprecedented availability of data (big data), (2) the data's behavioral nature providing fine-grained insights, (3) advanced computational capabilities to perform complex AI-based calculations.

Table 2: Multidimensional Categorization of People Analytics (HRIS = human resources information systems; *interviews includes expert panels, workshops, observations, focus groups; **workshops includes SWOT-analysis, balanced scorecards)

Dimension	Characteristic	Sources (Academic; *Practitioners)*
Scope	Core objectives in HR Function	(Baesens et al., 2017; Tursunbayeva et al., 2018; van den Heuvel & Bondarouk, 2017); (Fineman, 2016; Guenole et al., 2018)
	Long-term workforce planning	(Angrave et al., 2016; Marler & Boudreau, 2017; McIver et al., 2018); (Bachman et al., 2015; Fineman, 2016)
	Digital transformation	(Angrave et al., 2016; Simón & Ferreiro, 2018); (Fecheyr-Lippens et al., 2015; Silvestre et al., 2015)
Unit of Analysis	Individual	(van den Heuvel & Bondarouk, 2017); (Collins et al., 2017)
	Group/Organization	(Levenson, 2018); (Bachman et al., 2015; Fineman, 2016)
Data Structure	Structured	(Baesens et al., 2017); (Fern et al., 2014)
	Unstructured	(Angrave et al., 2016; McIver et al., 2018)
Data Sources	Digital Traces	(Hüllmann & Kroll, 2018; McIver et al., 2018); (Sweeney et al., 2016)
	Sensors	(Hüllmann et al., 2021); (Arellano et al., 2017)
	(Pulse) Surveys	(Angrave et al., 2016; Levenson, 2018); (Guenole & Feinzig, 2016)
	Interviews*	(Levenson, 2018); (Silvestre et al., 2015)
	HRIS	(Levenson, 2018); (Guenole & Feinzig, 2016)
	Video/Audio	(Hüllmann et al., 2021); (Collins et al., 2017)
	External Data Sets	(Baesens et al., 2017); (Fern et al., 2014)
Data Content	Personnel Data	(Baesens et al., 2017);
	Project Data	(Baesens et al., 2017; Levenson, 2018)
	Psychometric Data	(Arellano et al., 2017)
	Location	(Baesens et al., 2017; Simón & Ferreiro, 2018)
	Behavioral	(Kremer-Davidson et al., 2016); (Fineman & Solow, 2018)
	Market Data	(Marler & Boudreau, 2017); (Fern et al., 2014)
Quantitative Methods	Clustering	(Simón & Ferreiro, 2018); (Arellano et al., 2017; Fecheyr-Lippens et al., 2015; Fern et al., 2014; Guenole et al., 2018)
	Network Analysis	(Levenson, 2018); (Fern et al., 2014; Guenole et al., 2018)
	Null Hypothesis Significance Testing	(Simón & Ferreiro, 2018; van den Heuvel & Bondarouk, 2017); (Fern et al., 2014; Guenole & Feinzig, 2016)

	Machine Learning (Video, Audio, Text)	(Angrave et al., 2016; McIver et al., 2018; Shami et al., 2015); (Fecheyr-Lippens et al., 2015; Silvestre et al., 2015)
Qualitative Methods	Interview Coding, Workshops**	(Kremer-Davidson et al., 2016; Levenson, 2018); (Fecheyr-Lippens et al., 2015)
Consequences	Ethics & Legal	(Gal et al., 2017); (Guenole et al., 2017)
	Surveillance	(Hüllmann et al., 2021); (Guenole et al., 2017; Schwieters, 2015)
	Wellbeing & Stress	(Tursunbayeva et al., 2021); (Guenole & Feinzig, 2016)
	Statistical Issues validity, bias, discrimination	(Gal et al., 2020; Hüllmann & Mattern, 2020); (Guenole & Feinzig, 2016)
	Implementation change management, skillgap	(Hüllmann & Mattern, 2020); (Bachman et al., 2015; Guenole et al., 2017)

The differences between the identified people analytics' conceptions and traditional human resources information systems exacerbate the contentious debate. People analytics' novel characteristics cause negative consequences. Combining the novel extent of available data with the data's behavioral nature allows fine-granular tracing of employee behavior, depicted as the metaphorical panopticon (Hafermalz, 2021). Through extensively monitoring employee behavior, the panopticon inhibits the behavioral mechanisms theorized by Altman (1977) for reaching an individual's desired privacy outcomes. Conversely, fine-grained monitoring enables more precise decision models for personnel decisions, improving the effectiveness of human resource information systems on the operational level. Simultaneously, more data and advances in artificial intelligence technology enable decision support for less structured decision problems, that is, problems on the strategic level of managerial activity. Strategic people analytics with qualitative approaches or highly aggregated and anonymized data sources, however, is unproblematic in terms of surveillance—except for risks of reidentification or dehumanization.

This paper advances the understanding of next-generation human resource information systems and their organizational implications. It shows how the differences between operational and strategic people analytics' conceptions explain the controversial debate and the opposing viewpoints. It contributes to bridging the academic and practice divide. Academics' and practitioners' attitudes and purposes differ when talking about people analytics. Academics focus on introducing the topic, presenting state of the art, and providing an outlook for the future. While they

highlight the topic's relevance, they emphasize the issues. In contrast, practitioners focus on best practices and advertising people analytics products as the next evolution of human resources, emphasizing benefits and opportunities. The academic literature takes a more neutral perspective and tries to make sense of the practices associated with people analytics, whereas practitioners are more hands-on and pursue commercial interests. Summarizing the results, this paper contributes four tentative propositions based on people analytics' novel characteristics and the two overarching conceptions:

Operational Level People Analytics: (1) A large amount of behavioral data and computational advances (machine learning/AI) enable fine-grained insights for broader automation of structured personnel decision problems compared to traditional human resource information systems. **(2)** Operational people analytics, driven by academics and vendors, suffers from privacy concerns as individuals are monitored through large-scale behavioral tracking and quantitative analyses (=AI tools), which inhibit privacy regulation behaviors.

Strategic Level People Analytics: (3) A large amount of behavioral data and computational advances (machine learning/AI) enable more effective human resource information systems for less structured decision problems compared to traditional human resource information systems. **(4)** Strategic people analytics, driven by consultancies, does not suffer from privacy concerns (that much) as the relevance of daily fine-grained monitoring is reduced over aggregated data and qualitative approaches (=consulting practice).

5 Limitations and Conclusion: Moving People Analytics Forward

This paper's limitations include that only literature until 2021 was analyzed, although people analytics is a dynamic topic and changes occur quickly. Only a selection of large consultancies was considered, so generalizability to small and medium consultancies might be limited. The filtering was subjective, and other researchers might include different papers. Differentiating the conceptions based on a single dimension does not work because the same data sources or analytical methods can be used for both operational and strategic improvements, as methods such as machine learning are generic. Thus, it is crucial to consider the combination of scope, analytical methods, and data sources that make up a conception. Due to space

limitations, not all conceptual details could be fused out. Instead, the multidimensional categorization and the two conceptions are briefly depicted before outlining the theoretical propositions. So far, the results remain conceptual, and empirical evidence for the propositions is lacking. The next steps are adjusting the multidimensional categorization according to peer feedback and validating the suggested propositions with an online experiment (Schulz et al., 2010). Concluding, this paper contributes four propositions that advance the theory of people analytics. The gap between academia and practice is highlighted. Managers are encouraged to consider the academic discourse on people analytics and be aware of the different conceptions. These different conceptions have divergent implications that must be addressed when implementing people analytics.

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Appendix

The literature review followed recommendations by Jan vom Brocke et al. (2009). Google Scholar was used to add manuscripts that might be missing from Scopus or Web of Science. Unfortunately, the exact numbers were not documented for Google Scholar. The consultancies were selected so that relevant input for the research question is available.

Search Results for Academic Papers				
	Web of Science	Scopus	Google Scholar	Total
People Analytics	49	67	(n/a)	
Workforce Analytics	35	53	(n/a)	
Workplace Analytics	1	3	(n/a)	
Human Resources/HR Analytics	63	98	(n/a)	
Social Analytics	58	99	(n/a)	
Total	206	320	(n/a)	
Total after removing duplicates	188	304	(n/a)	
Total after merging				**280**

Search Results for Consultancies Papers	
Deloitte	14
Capgemini	3
Accenture	13
PwC	11
KPMG	5
McKinsey	7
EY	1
BCG	3
IBM	8
Total	**65**

Filter	**Academic Papers**	**Consultancies Papers**	**Total**
After search	280	65	
After screening abstract	60	(n/a)	
After screening fulltext	28	14	
Total papers included in analysis			**42**

THE IDENTIFICATION OF ETHICAL FOCUS AREAS: A LITERATURE STUDY INTO DATA MINING ETHICAL FOCUS AREAS

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Abstract Improper use of data must be avoided, as the consequences of improper use of data can be catastrophic. In the design of information systems, ethical focus areas could help combat improper use of data. Currently, more research is available on ethical focus areas in Data Mining compared to related research fields of Data Mining, such as Decision Mining and Process Mining. For this paper, a theoretical review was conducted to identify ethical focus areas of Data Mining and their possible solutions. Seven ethical focus areas were identified focussing on privacy, collection of personal information, consent, unpredictability and inaccuracy, group profiling and biased data. Future research is needed on the ethical focus areas, to validate the possible solutions related to these ethical focus areas in the context of related research fields of Data Mining.

Keywords: data mining, ethics, ethical focus areas, decision mining.

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1 Introduction

The value of data is determined by the techniques used to understand the data based on the context the data comes from or is placed in (Calders & Custers, 2013). Credit card fraud (Bhattacharyya et al., 2011), heart disease (Purusothaman & Krishnakumari, 2015) and terrorism (Thuraisingham, 2020) are all examples of a variety of serious (societal) problems for which Data Mining offers a solution. Data Mining is a technique that consists of machine learning, statistics, visualization (Calders & Custers, 2013; Wahlstrom et al., 2006), databases (Wahlstrom et al., 2006) and artificial intelligence (Calders & Custers, 2013). Data Mining is defined as "*the automated process of analyzing large sets of data and then extracting patterns in the data.*" (Kulkarni et al., 2010, p. 1). It is known for the benefits it offers to public and private sectors (Schermer, 2011). For example, Data Mining can benefit consumers when their information is used to take up less of the consumer's time by rearranging a store based on products purchased together (Payne & Trumbach, 2009). In addition to benefits, Data Mining also has drawbacks that raise ethical focus areas regarding privacy through the improper use of its data processing methods (Schermer, 2011). For example, serious problems such as identity theft and discrimination occur when consumers provide personal information (Payne & Trumbach, 2009). This paper discusses the ethical focus areas present in the Data Mining research field.

Multiple research fields address ethical focus areas. For example, AI (Brendal et al., 2021) and databases (Chadwick & Berg, 2001). AI and AI ethical focus areas can be considered too broad for the specific application of Data Mining, where each research field has their overlapping, but also their specific solutions. To reveal these specific ethical focus areas and solutions, we, therefore, solely focus on Data Mining in this study. With the goal to ultimately design and deploy ethical Data Mining techniques. This raises the following research question: "*What ethical focus areas could be retrieved from Data Mining research that can be used in sub-research fields of Data Mining?*" Sub-research fields of Data Mining include Decision Mining and Process Mining. Identifying focus areas may also be relevant to these fields. The remainder of the paper is structured as follows: first, the background and related work that provides further insight into the topic is being discussed. Second, the research method used to collect and analyze data is presented. Third, the use of a theoretical review as a data collection technique is detailed. Fourth, the results of the theoretical review are

defined. Fifth and lastly, the research is concluded, followed by a discussion and possible future research directions.

2 Background and Related Work

The growing world of technology offers many opportunities when it comes to processing data with Data Mining solutions (Pal, 2011). Data Mining is a method aimed at discovering useful information and data patterns that emerge from a collection of analyzed data (Kulkarni et al., 2010; Pal, 2011; Payne & Trumbach, 2009). It analyzes information from a database (Payne & Landry, 2012) to make discoveries about this information (Cary et al., 2003). Data Mining is also referred to as knowledge discovery because it is not always apparent what information is being discovered (Cary et al., 2003). The analyzing process is performed using analytical tools and techniques (Pal, 2011). The most common applications that Data Mining offers are: security, efficiency, product innovation and customer service (Payne & Trumbach, 2009). For example, it can help with marketing that is more targeted to specific consumers (Cary et al., 2003) or cleaning data before using it for a different purpose (Payne & Landry, 2012). The use of Data Mining can create ethical problems around, for example, the violation of consumers' privacy since personal information is involved (Cary et al., 2003). Thus, despite the benefits of Data Mining, it certainly presents ethical challenges (Johnson, 2014, 2018).

When research extends on existing solutions to tackle new problems, according to research by Hevner and Gregor (2013), these solutions can be adopted from any related research field. Related fields to Data Mining are e.g. Process Mining (van der Aalst, 2011) or Decision Mining (Leewis, Smit, et al., 2020; Rozinat & Aalst, 2006). Process Mining focuses on the discovery of processes from event logs, conformance checking of process models, and the enhancement of process models (van der Aalst, 2011). Decision Mining focuses on the discovery of decisions from decisions logs, conformance checking of decision models, and the improvement of decision models (De Smedt et al., 2017; Leewis, Berkhout, et al., 2020; Leewis, Smit, et al., 2020). Both Process Mining and Decision Mining utilize Data Mining techniques (Leewis, Smit, et al., 2020). Therefore, the authors argue that any ethical focus area identified with regards to Data Mining can be adopted in the related fields of Data Mining and vice versa.

3 Research Methods

The purpose of this paper is to explore what ethical focus areas of Data Mining can be identified in literature. Therefore, the focus of this research should be on existing research related to this topic. To achieve this, a theoretical review is conducted (Paré et al., 2015). A theoretical review looks at an emerging problem and that the research in question should address this problem or support it with new research based on existing research (Paré et al., 2015). This will be done based on other scientific papers that contain ethical focus areas about Data Mining. The collection and analysis of these scientific papers is done using a protocol, as shown in figure 1.

4 Data Collection and Analysis

Over a period of four months, between November 2021 and February 2022, a theoretical review was conducted where scientific papers were found using Google Scholar in line with the systematic review approach and phases described by Snyder (2019). Franceschet (2010) recommends using Google Scholar when it comes to topics related to computer science. Google Scholar has a broader selection of cited papers on a wider range of topics than, for example, Web of Science has (Franceschet, 2010; Harzing & Alakangas, 2016). Two search queries are utilized for retrieving articles related to ethical focus areas in data mining. The first search query is that of *ethics in Data Mining*. This includes the possible publications concerning ethical issues in Data Mining. The second search query is that of *ethical Data Mining*. This covers the possible publications related to the field of ethical Data Mining, which is a slight nuance compared to the first query. Applying these queries resulted in the following number of results using Google Scholar collected within the first two weeks of November 2021: 45 papers were found with the search term *ethics in Data Mining* and 104 papers were found with the search term *ethical Data Mining*. Papers were excluded on being non-English, duplicate papers, and being anything other than a book, conference proceeding or journal paper. This resulted in a set of 64 papers (21 *ethics in Data Mining* and 43 *ethical Data Mining*), as shown in Figure 1. The papers were then reviewed by three reviewers based on title, abstract, and full paper review rounds. The reviewers did this separately for all three rounds. After a review, the results were discussed to decide for each paper whether it will be included or not. This resulted in 27 relevant papers after the title review, 20 relevant papers after the abstract review and 19 relevant papers after the full paper review.

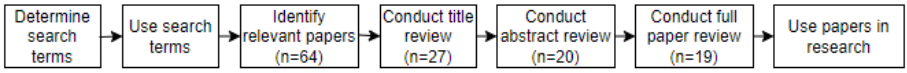


Figure 1: Review Protocol

All resulting papers were reviewed against the selection criteria using two questions: 1) The paper is published in a conference proceedings, book or journal, is English and not duplicate. 2) The paper addresses the combination of ethics and Data Mining. The first question was asked during the identification of papers and the second during all review rounds. The coding of the ethical focus areas was performed by one researcher and by fully analyzing each paper, a general topic (ethical focus area) could be identified, thus coding the article under that specific topic. An additional researcher was consulted when there was doubt about which ethical focus area could be identified. Each article was also analyzed for possible solutions to combat problems related to a specific ethical focus area.

5 Results

The theoretical review resulted in 19 papers that were deemed relevant for this research dating from 2002 to 2021. After analyzing the papers, a number of ethical focus areas could be identified. These ethical focus areas are: 1) privacy, 2) collection of personal information, 3) consent, 4) Data Mining unpredictability, 5) Data Mining inaccuracy, 6) group profiling, and 7) biased data. In addition, most of the identified ethical focus areas are presented with possible solutions, which were also identified from the analyzed 19 papers.

5.1 Area 1: Privacy

The first ethical focus area is that of privacy. Through the use of the internet and the digital economy, we create digital data structures that include information about our work, education, health, and entertainment, and these data structures are stored in various places such as hotels, airlines, and banks. However, these data structures can also be used to find out more personal information about an individual. The method that makes this possible is Data Mining and this raises a number of ethical privacy concerns when used by business organizations and government agencies (Shahidullah & Hossain, 2009). Moreover, within the U.S., for example, there is not

yet a legal framework available for protecting the privacy of individuals when Data Mining is used by the businesses or governments (Sprague, 2009).

The use of Data Mining processes in organizations often seems to benefit an individual, but the individual's personal information is not always kept private (Robinson, 2015). Although individuals fear potentially losing their privacy, they still often want the benefits Data Mining offers (Dean et al., 2016). For example, benefits such as targeted marketing, discounts, money and time savings. However, if a consumer wants to gain benefits within an organization, he or she must often give away personal information (Payne & Trumbach, 2009). In addition, organizations and websites can track a lot of an individual's online behavior (Cook & Cook, 2002; Robinson, 2015). This could be dangerous and harmful when this information is disclosed to unauthorized individuals. For example, it could be harmful when you or someone close to you has a terminal illness and you start to receive information about questionable cures (Cook & Cook, 2002).

There are also concerns about privacy violations within U.S. Data Mining programs. After the terrorist attack on the New York World Trade Center on September 11 2001, there has been an increase in the establishment of federal Data Mining programs. Privacy concerns also increased with the use of personal information within these Data Mining programs, such as emails, bank accounts, or social security numbers (Shahidullah & Hossain, 2009).

5.2 Area 1: Possible Solutions

Individuals will continue to use the internet even though there is a threat of organizations misusing personal information through Data Mining processes. Therefore, it is important that there are more built-in privacy protections for the internet as this is not available now. This will ultimately benefit both individuals and organizations (Robinson, 2015). Unfortunately, an individuals' behavior on websites will not always be completely anonymous, but it is important that organizations provide options, such as Virtual Private Networks (VPNs), not being tracked and blocking cookies with the use of a program to allow an individual to act as anonymously as possible (Robinson, 2015). After all, it is in the interest of an organization to engage in proper privacy processing. If they make a mistake in this regard, it is not only bad for the individuals involved, but also for the image of the

organization (Cook & Cook, 2002). Robinson (2015) used a Rawlsian ethical approach to analyze the ethical implications of Data Mining of three major codes of ethics used by American marketing firms. Rawls's ethics focus on among others the protection of the least advantaged in society and that anonymity should be a primary good for individuals as a form of self-protection on the internet. Robinson concluded that the code of ethics needs to be reviewed and updated and that there needs to be more clarity on what digital ownership means within the codes of ethics. A definition like this can then be used by organizations when making choices about the use of an individual's personal information. In addition, consumers should be allowed to make more informed choices as organizations are more open about the use of personal information through clear policies on how an individual's personal information is used. Despite the difficulty of achieving this, the goal is for consumers to have more control over their personal information (Robinson, 2015). Dean et al. (2016) also indicate that it is good for a business to establish a code of ethics because, among other things, it positively influences the relationship between the business and its external stakeholders. Lastly, Oliveira and Zaïane (2009) propose a privacy-preserving clustering method called Dimensionality Reduction-Based Transformation (DRBT). This method transforms a database so that the objects within the dataset retain the similarity but no longer resemble the original database. This allows the database to be used for clustering while maintaining privacy, accuracy of the process, and also allows a dataset to be securely shared between organizations at a reduced cost. Violating an individual's privacy stems from multiple problems, such as the unethical collection of personal information and the deprivation of consent.

5.3 Area 2 and 3: Collection of Personal Information and Consent

The second and third ethical focus areas are the collection of personal information and consent. All stages of Data Mining raise ethical concerns related to personal information, especially the collection of the data prior to the Data Mining process (Cary et al., 2003). In criminological articles, for example, ethical considerations around data collection are often not addressed by the researcher (Brewer et al., 2021). Organizations are increasingly collecting personal information without the average individual being aware and this is becoming more common. The collection of this personal information is done in a variety of ways, such as through cookies or registration forms (Cary et al., 2003; Payne & Landry, 2012). Information can also

be collected by using web crawlers, which are programs that download web pages from the internet. This brings problems, such as higher costs for website owners due to the bandwidth used for websites during web crawling or the creation of lists that contain emails for spam (Thelwall & Stuart, 2006). Individuals often fail to see the risk they put themselves at when they choose to share personal information for benefits within organizations. These can be risks related to identity theft, phishing schemes, mail fraud, or discrimination (Robinson, 2015). Furthermore, the danger of collecting personal information is that the individuals about whom the information is about have no control over their information, but they are the ones who are disadvantaged by the inaccuracy of Data Mining (Payne & Landry, 2012; Payne & Trumbach, 2009). However, an economic justification for collecting personal information would be that it allows organizations to communicate with individuals in a more targeted way (Fogel, 2006).

Personal information may be used without informing the individual concerned (Cary et al., 2003; Payne & Landry, 2012; Robinson, 2015). Not to mention, information someone puts online can be used for something completely different than its original purpose (Cook & Cook, 2002; Danielson, 2009; Payne & Landry, 2012). The fact that individuals are not always well informed by organizations about the use or consequences of their personal information deprives them of the opportunity to give informed consent (Payne & Landry, 2012). It cannot be assumed that an individual knows exactly what they are consenting to when they give an organization permission to collect personal information (Fogel, 2006). Additionally, it is a major problem when an individual's personal information, which he or she has chosen to share online on a particular organization's website, is used by multiple organizations without their knowledge or consent (Robinson, 2015). Also, organizations often assume that an individual gives consent when he or she uses the organization's services (Cary et al., 2003). In the U.S., for example, consent is deemed to have been given for linking an individual's profile to the telephone number disclosed by a toll-free service when individuals use such a toll-free number (Danielson, 2009). Lastly, when an individual does give consent, organizations do not give an individual the opportunity to withdraw that consent (Cary et al., 2003). Another problem are the privacy policies that individuals have to agree to before they can make use of a service. These are difficult to read, understand or not even followed by the organization (Cary et al., 2003). Implementing a proper privacy policy is already a

challenge because the concepts surrounding privacy are complex in themselves (Dean et al., 2016).

5.4 Area 2 and 3: Possible Solutions

Using Data Mining in an ethical manner works by collecting data in an honest way and informing the individual that he or she may, or may not, be monitored (Wowczko, 2013). When data is collected through the use of web crawlers, it is important that privacy is considered without making assumptions that web page owners will consider this in their interest (Thelwall & Stuart, 2006). In addition, it is important for organizations to be more open about collecting personal information and how they use that information to benefit individuals (Fogel, 2006). An organization could implement a Data Mining policy that focuses on collecting information, but there are often drawbacks to this. For example, a policy that optimizes consequences for those who are affected by Data Mining is hard to achieve because it is difficult to map out all the consequences. Further, if you are dealing with a policy that prohibits Data Mining processes if they violate privacy you are again dealing with drawbacks such as very clear communication and constantly asking individuals for permission (Cary et al., 2003). Dean et al. (2016) suggest a few practices for establishing online privacy policies for businesses, such as letting an individual know that their data is being collected or what Data Mining practices are being used within the business. Furthermore, Payne and Landry (2012) mention that personal information that is collected should be secured by the individual that collects it. Organizations should use security measures, such as data encryption, that prevent the use of personal information without consent or anonymity tools. Finally, if researchers do not wish to seek consent from individuals, it is important that they can prove that the research, including the collection of data and reporting of results, will have virtually no negative impact on these individuals (Brewer et al., 2021). Problems surrounding Data Mining do not only affect the privacy violation of an individual, but the Data Mining process itself also plays a role in this.

5.5 Area 4 and 5: The Unpredictability and Inaccuracy of Data Mining

The fourth and fifth ethical focus areas are unpredictability and inaccuracy of Data Mining. Decisions in our society that are based on Data Mining do not sufficiently consider the privacy of an individual. When making a decision, more thought is given

to avoiding costs and making a profit. This can be problematic when Data Mining uses sensitive datasets, such as medical datasets (Roddick & Fule, 2004). A counterargument to this may be that Data Mining is unpredictable (Roddick & Fule, 2004). It is known for discovering unknown relationships between data (Cary et al., 2003; Cook & Cook, 2002; Johnson, 2018; Payne & Landry, 2012; Shahidullah & Hossain, 2009). Therefore, it is not known in advance what kind of information will be found in the Data Mining process (Cary et al., 2003; Roddick & Fule, 2004). But due to the unpredictability of Data Mining, problems still arise such as that it is difficult for an organization to properly provide the opportunity for informed consent. As well as, that the unpredictability of Data Mining also reveals information about an individual that he or she does not want to disclose and when this information is spread it could have harmful consequences if it is revealed to the wrong kind of people (Payne & Landry, 2012; Payne & Trumbach, 2009). When it comes to sensitive data about an individual in health care databases, such as life expectancy or drug use, these types of people may base decisions about mortgages, for example, on this type of information (Gál et al., 2014). When criminals can obtain more personal information about a person by using Data Mining. This can lead to unpleasant consequences, such as identity theft (Christen et al., 2014).

In addition, the Data Mining process is not perfect which can cause mistakes (Cook & Cook, 2002). These mistakes happen because e.g., sensitive information often has an expiration date or the method of data collection is not accurate (Cary et al., 2003). For example, information about the same person is considered two different people or information is linked to the wrong person, which makes the information used in a Data Mining process inaccurate (Cook & Cook, 2002). Individuals may be judged based on incorrect information and they do not have the option to change their personal information (Cary et al., 2003). Another problem is that the relationships that emerge from Data Mining are often perceived for the fact that they are probably correct (Johnson, 2014, 2018) or that organizations assume Data Mining is very accurate when this is not the case (Payne & Trumbach, 2009). This can lead to unnecessary actions that have no consequences (Johnson, 2014, 2018). Lastly, it is important that the results of Data Mining are not influenced by the individual who allows the Data Mining process to take place or the individual who provides the data (Wowczko, 2013).

5.6 Area 4 and 5: Possible Solutions

Roddick and Fule (2004) present a system that is used to filter the results of Data Mining for sensitivity before these results are used in a decision-making process. The system takes into account data sensitivity by checking the rules of Data Mining. They consider this to be a partial solution for addressing privacy protection, stereotyping and the use of sensitive data. Data anonymization methods can also be used to prevent re-identification of an individual when sensitive data is involved, for example linking a piece of data to multiple individuals or adding noise to data, but this leads to a significant reduction in the quality of the data. Unfortunately, the validity of the results of Data Mining depends on the quality of the data (Gál et al., 2014). However, Cary et al. (2003) recommend ten practices for developing Data Mining systems that help maintain healthy relationships between organizations and individuals. These include evaluating the quality of the data used for Data Mining. Lastly, Wowczko (2013) says that to prevent the influences on the Data Mining results an expert should check the results to ensure they are correct and legitimate, taking into account any assumptions, limitations and faults made in the research. Finally, among the problems already mentioned is the categorization of individuals and having biased data which causes the violation of the privacy of an individual.

5.7 Area 6 and 7: Group Profiling and Biased Data

The sixth and seventh ethical focus areas are group profiling and biased data. group profiling is the categorization of individuals into groups based on associations about these individuals (Christen et al., 2014). For example, students are placed in a group during the Data Mining process based on a set of characteristics. These groups will encourage students to do what fits their profile or matches them with an outcome that best fits their skills and not necessarily the student's interests. A counter-argument may be that students do not always know what they want because they are young and the consequences of making a big choice can be costly. However, this should still not undermine a student's individuality (Johnson, 2014, 2018). Cary et al. (2003) give the hypothetical example of a bank asking an individual to fill out a form that is about interests and lifestyle factors when they open a bank account. This individual is then categorized into a bad credit risk group after the data from the form is mined and correlation takes place. As a result, an individual is then not kept informed of certain services or even denied a loan based on the group he or she is

in. This makes the Data Mining process biased, which brings us to the topic of biased data.

In some cases, the construction of data is negatively influenced from the outside either intentionally or unintentionally, and these negative influences will be reflected in the data. Often this type of data comes into contact with individuals who utilize the services of bureaucratic organizations, but not every individual comes into contact with such an organization to the same degree, so privilege can seep into the data. The data begins to reflect the social privileges of these frequently encountered individuals and underrepresents those individuals who do not have much contact with the data. For example, minorities are reluctant to provide health data because they fear the government will use it to their detriment or, if they eventually do choose to share their data, they are excluded from the dataset. In addition, for example, the wrong assumption is made that individuals are adequately informed about the topic to which the data relates during data collection (Johnson, 2018). If this type of biased data is used in Data Mining, the results will also contain biased data.

No possible solutions were identified for group profiling and biased data.

6 Conclusion, Discussion and Future Research

As machine learning techniques, such as Data Mining, evolve, so do the ethical implications. Therefore, it is important to take the opportunity to address these ethical focus areas continuously. These ethical focus areas help to ultimately design and deploy ethical Data Mining techniques. The following research question is addressed: "*What ethical focus areas could be retrieved from Data Mining research that can be used in sub-research fields of Data Mining?*" A theoretical review was conducted that resulted in 19 papers that were analyzed from which seven ethical focus areas in Data Mining were identified. Seven ethical focus areas were identified together with possible solutions. From a theoretical viewpoint, this research contributes to the body of knowledge of Data Mining. It also provides a starting point of ethical focus areas that can be adopted in sub-research fields of Data Mining and serve as a future research direction. This has the potential to support, for example, ethical Decision Mining and Process Mining by design, also avoiding common ethical issues existing in Data Mining. From a practical viewpoint, this research contributes to practice because it makes researchers and practitioners alike think about the problems

surrounding these ethical focus areas and what solutions, if any, there are or should be. The results and especially the possible solutions could guide the design and offers a way to structure the thinking of professionals designing and applying solutions for Data Mining and sub-research fields of Data Mining. Furthermore, because these ethical focus areas are made explicit, their impact on the design can be measured and evaluated explicitly. This has high potential because doing so in the design phase of Data Mining solutions decreases the risks of improper use of its underlying and resulting data. The necessity of this is confirmed frequently considering the scandals at different organizations getting negative attention from the press as well as from regulatory authorities.

The following limitations should be taken into account when utilizing the seven focus areas. The oldest paper dates from 2002, which is almost twenty years ago. It could be said that the information in these papers is outdated. However, more recent papers used in this study cite these older papers. Moreover, the information in these older papers is consistent with more recent papers and there was no impression that it was outdated. In addition, the coding of the ethical focus areas was done by a single researcher. This may compromise validity. Any future research should focus on involving additional researchers in coding the ethical focus areas. Furthermore, to the researchers' knowledge, no solution exists to avoid unwanted group profiling and biased data. Therefore, future research on this topic is needed. Additionally, the identified ethical focus areas should be validated in the respective sub-research fields of Data Mining, such as Decision Mining and Process Mining, in order to establish the ethical focus areas and should not be limited to only literature studies. As Hevner and Gregor (2013) pointed out, related research fields can adopt solutions from each other. With this rationale, the identified ethical focus areas are also relevant to related and sub-research fields of Data Mining. Future research should focus on empirical validation and the implementation of the ethical focus areas in order to impact the way people and organizations handle ethically.

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Preparing Future Business Data Sharing via a Meta-Platform for Data Marketplaces: Exploring Antecedents and Consequences of Data Sovereignty

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Abstract Meta-platforms have received considerable Information Systems scholarly attention in recent years. Meta-platforms enable platform-to-platform openness and are especially beneficial to amplifying network effects in highly-specialized markets. A promising emerging context for applying meta-platforms is data marketplaces—a special type of digital platform designed for business data sharing that is vastly fragmented. However, data providers have sovereignty concerns: the risk of losing control over the data that they share through meta-platforms. This research aims to explore antecedents and consequences of data sovereignty concerns in meta-platforms for data marketplaces. Based on interviews with fifteen potential data providers and five data marketplace experts, we identify data sovereignty antecedents, such as (potentially) less trustworthy data marketplace participants, unclear use cases, and data provenance difficulties. Data sovereignty concerns have many consequences, including knowledge spillovers to competitors and reputational damage. This study is among the first that empirically develops a pre-conceptualization for data sovereignty in this novel context, thus laying the groundwork for designing future data marketplace meta-platform solutions.

Keywords: data economy, data sharing, data sovereignty, data markets, platform ecosystems, platform openness, meta platforms.

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1 Introduction

Studies on *meta-platforms* represent a growing field within Information System (IS) literature, especially in a research stream related to multiplatform ecosystems (e.g., Floetgen et al., 2021, Peters et al., 2021). A meta-platform is a platform of platforms, which coordinates, integrates, and connects various existing platforms (Zhang and Williamson, 2021). More recently, there has been a surge of interest in meta-platform research to enable business data sharing among companies, particularly by enabling platform-to-platform openness in niche markets that require high degrees of specialization (e.g., Mosterd et al., 2021, Veile et al., 2022).

Concurrently, recent trends in the European Data Economy have proliferated data marketplace research in IS literature (e.g., Fruhwirth et al., 2020, van de Ven et al., 2021). Data marketplaces are B2B digital platforms that enable secure data sharing between data providers and consumers by providing necessary governance models and infrastructure (Lis & Otto, 2020). The current market landscape in such marketplaces is vastly fragmented, causing expensive vendor lock-in and data discovery difficulties (European Commission, 2020b). Therefore, this fragmented nature opens an opportunity to explore meta-platforms within the data marketplace context. In fact, the European Union has invested in many meta-platform initiatives to achieve a single European Data Market by 2030 (e.g., the GAIA-X[1] and i3-Market[2]). One potential use case of a meta-platform can be described as follows: data providers that are not associated with any marketplaces can directly join a meta-platform to share their business data. In doing so, data providers can reach out to and interact with data consumers from many participating marketplaces.

While meta-platforms are important for amplifying data marketplace network effects, meta-platforms may suffer from one significant challenge related to data sovereignty. Data sovereignty generally refers to the ability to decide and control data usage terms (Lauf et al., 2022). Prior literature highlights that data sovereignty concerns, particularly the risk of losing control over data, hinder data providers' adoption of data marketplaces (Spiekermann, 2019). Data sovereignty concerns have serious consequences. For example, competitors of data-providing companies may benefit from the shared data in unexpected ways (Gelhaar & Otto, 2020).

[1] https://www.gaia-x.eu/ accessed on May 16, 2022
[2] https://www.i3-market.eu/ accessed on May 16, 2022

Considering that these meta-platforms for data marketplaces are to be designed responsibly and utilized, we need to understand data sovereignty concerns in this novel context. We argue that data providers inherit unresolved data sovereignty concerns in the data marketplaces, triggering fears of losing control over data in meta-platforms. Even more, the risk may amplify since data moves across many marketplaces. Nevertheless, data sovereignty concerns in the meta-platform context are currently underexplored. Therefore, **this research aims to explore antecedents and consequences of data sovereignty concerns in the context of a meta-platform for data marketplaces.** We find ten antecedents and four consequences of data sovereignty concerns. The findings can be used to theorize data sovereignty in this emerging context by deriving testable propositions concerning the identified antecedents and consequences.

2 Background

2.1 Data Governance Domains for Data Platforms

We will structure our analysis based on data governance literature for data platforms (Lee et al., 2017; van den Broek & van Veenstra, 2015). This approach is relevant because data governance generally explores issues revolving around control over data ownership, access, and data usage decisions (Lis & Otto, 2021). We consider three data governance domains as a starting point: a) data governance mode, b) data ownership and access, and c) data usage. The *data governance mode* domain explores the decision rights allocation for involved actors and the appropriate mode to adapt (i.e., market, bazaar, hierarchy, or network) (van den Broek & van Veenstra, 2015). Next, the *data ownership and access* domain examines the criteria and allocation for ownership and access. This domain also discusses the contribution estimation for involved actors and the use cases definition (Lee et al., 2017). Finally, the *data usage* domain defines conformance (such as audit process), monitors data usage in data platforms, and ensures provenance to track all data history (Lee et al., 2017).

2.2 Data Sovereignty Concerns in Data Marketplaces

Due to a general paucity of meta-platform research, we will examine data sovereignty concerns in the literature on data marketplaces. Previous studies on meta-platforms also employ this approach to draw the theoretical foundations from (or inspired by) their object of the federation (e.g., Zhang & Williamson, 2021). We will first discuss the antecedents of data sovereignty, which can be classified into the data governance domains presented in Subsection 2.1: a) data governance mode, b) data ownership and access, and c) data usage.

We did not find any data sovereignty antecedents that belong to the *data governance mode* domain—even after reflecting on two recently published data marketplace literature reviews (see Abbas et al., 2021, Driessen et al., 2022). One potential explanation is that the current actor definitions, including their roles and responsibilities, have been adequately well-defined in the extant literature.

In the *data ownership and access* domain, vague data ownership definitions cause data sovereignty concerns (Hummel et al., 2021). Currently, (legal) instruments and models for exercising data ownership are generally less clearly defined due to the nature of data as an experience good (Koutroumpis et al., 2020). Hence, data providers have insufficient guidance in properly defining data ownership and access (Martin et al., 2021). Data policy divergence also causes difficulties in ensuring data sovereignty. For example, the United States lacks explicit database rights, Australia's copyright law safeguards databases, and Canada's approach falls somewhere in between (Koutroumpis et al., 2020). Therefore, keeping up and complying with multiple policy requirements is generally challenging (Scaria et al., 2018). In addition, data sovereignty is hardly achieved due to unclear use cases in the first place, making it ambiguous to define appropriate access for data consumers (Scaria et al., 2018). Finally, the vast amount of data type variation (e.g., multimedia, raw, or machine learning models) also contributes to data sovereignty concerns because data marketplaces need to accommodate appropriate protection mechanisms for each data type (Fernandez et al., 2020).

Related to the *data usage* domain, data providers often face data withdrawal issues. Data sovereignty mandates data providers to accommodate consent revocation from their end-users if requested. Nevertheless, revoking the data access in such

marketplaces, for example, via consent management, is still technically challenging (Xu et al., 2021). Another mentioned antecedent is data provenance difficulties, referring to an inability to track the origin and altered data due to a unique property: data is a non-rivalrous good that can be duplicated inexpensively and utilized concurrently by others (Koutroumpis et al., 2020). Finally, unverified data consumers also cause sovereignty concerns because they may enter the internal system and access confidential information of data providers (or even their end-users) (Lauf et al., 2022).

Data sovereignty has many undesired consequences. Losing control over data is commercially sensitive due to knowledge spillovers (Koutroumpis et al., 2020). Competitors of provided data may benefit from companies that provide data in unanticipated ways, thus jeopardizing their business interests (Spiekermann, 2019). Moreover, data providers also experience data investment loss because free-riding parties may get "free" datasets without sufficient contributions to data providers. When this is the case, data prices fall below the reproduction marginal cost, which is often near zero (Martens et al., 2020). Data providers are also likely to deal with legal liabilities in the case of data misuse by data consumers. For example, GDPR breaches due to inabilities to protect the privacy of their end-users trigger substantial fines and penalties[3]. In addition, data providers generally experience reputational damage in the case of data breaches (Karger, 2020).

3 Research Approach

This study is exploratory because little is known about data sovereignty concerns of business data sharing via a meta-platform for data marketplaces. Given its flexibility, qualitative research is frequently used for exploratory research (Sekaran & Bougie, 2016). We need flexibility when conducting interviews because business data sharing in this context is not yet a well-defined concept. Therefore, often follow-up conversations are required to trigger further explanations from the participants' initial views. Moreover, probing questions are frequently needed to obtain deeper insights in an exploratory study. Hence, this study employs semi-structured interviews as a primary data collection method to support these follow-up and probing conversions (Edwards & Holland, 2013).

[3] https://gdpr-info.eu/issues/fines-penalties/ accessed on May 16, 2022

We employed the judgment sampling approach: selecting our interview participants by considering their expertise (Sekaran & Bougie, 2016). We chose this strategy because we examined a novel phenomenon only a few people understand (cf. Etikan et al., 2016). We aimed to interview data providers and marketplace experts to explore and confirm data sovereignty concerns in the meta-platform context. The criteria for selecting the interviewees were: 1) familiarity with data marketplaces (i.e., know about, have experienced, or have thought of), 2) experience in decision-making activities related to business models or data governance, 3) English fluency.

For potential providers, we were interested in respondents employed by large companies (i.e., companies with 250+ employees) operating in the EU. Large companies generally generate a vast amount of data and have more resources to actively participate in the Data Economy (European Commission, 2020a). We focused on the EU because meta-platform initiatives are expected to flourish due to the availability of policy agendas that support cross-exchange business data sharing in the EU. For experts, we selected participants involved in a meta-platform project because they can provide additional insight into data sovereignty threats. Thus, we interviewed fifteen potential data providers and five data marketplace experts (I-01 to I-15)—See Appendix 1 in the supplementary material for the overview of the participants)[4]. We conducted the online interviews via Microsoft Teams between July and November 2021. The average duration of the interviews was 40 minutes.

We developed a preliminary interview protocol and conducted two pilot interviews to test and refine our protocol. The interviews were divided into three sections (See Appendix 2 in the supplementary material for the detailed protocol). First, we asked about the interviewee's background and knowledge of data marketplaces. Second, we presented the concept of meta-platforms for data marketplaces with a specific use case illustrated in Section 1. Participants could ask for clarifications after the short presentation. We then asked about potential value propositions and hindrances related to a meta-platform for data marketplaces—These questions are essential to check conceptual alignments between the interviewee and the participant. Finally, we questioned the participants about data sovereignty concerns in this specific context. With the interviewees' permission, the interviews were recorded and

[4] The supplementary material can be accessed here: https://doi.org/10.4121/19762360

anonymously transcribed. We sent back the transcription to the participants and asked for their approval, resulting in minor changes for five transcriptions.

We deductively analyzed each interview transcript using Atlas.TI 9.1. The deductive analysis is suitable for an exploratory study (Casula et al., 2021), particularly when we want to compare a specific issue from a previously known context (i.e., data sovereignty in data marketplaces) to a novel phenomenon (i.e., meta-platforms) (Elo & Kyngäs, 2008). We developed an *unconstrained categorization matrix* to code a block of statements into relevant (sub)categories. This matrix is flexible, allowing us to induct new (sub)categories. For instance, we coded *lineage chain limitation* for the following excerpt: "You do not even know a lot about the lineage chain, what is the data behind it?" (I-07); we assigned *unidentifiable dataset* to this sentence fragment: "And there are many good practices that have been developed and that the data markets community doesn't know. For instance, a completely basic principle is to have persistent identifiers. Now, you need to be able to somehow identify datasets in order to be able to for them to be uniquely identifiable within a network" (I-18). Next, we synthesized and grouped those two initial codes into the sub-category of **data provenance difficulties,** which belongs to the **data governance mode** category. We conducted an intercoder reliability check to increase the internal validity of our code (O'Connor & Joffe, 2020), resulting in an overall agreement between coders. The full description of the unconstrained categorization matrix can be found in Appendix 3.

4 Result

Figure 1 pre-conceptualizes the antecedents and consequences of data sovereignty concerns in a meta-platforms for data marketplaces (developed based on the interview findings). We identify ten antecedents, which can be classified into the three main categories described in Section 2.2; we also identify four consequences of data sovereignty concerns.

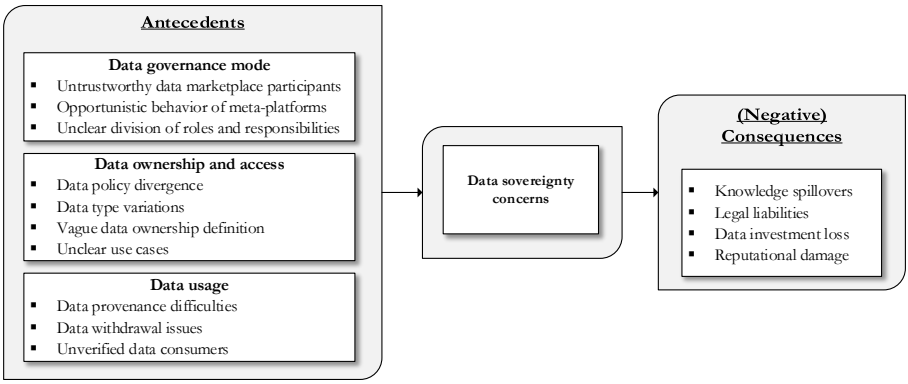


Figure 1: A pre-conceptualization of the antecedents and consequences of data sovereignty concerns in business data sharing via meta-platforms for data marketplaces

We first describe our findings concerning the antecedents that belong to the *data governance mode* category. Owners of meta-platforms need to find participating data marketplaces, but some interviewees questioned whether such **marketplaces are trustworthy.** Data providers are suspicious if specific marketplaces are disreputable intermediaries (I-04). One interviewee (I-01) said: "If a channel [a data marketplace], for instance, is ruled by mafias, you will try to avoid it." Evaluating such marketplaces is problematic because each has its unique operation rules (I-01). For example, while some marketplaces have decent security, others do not (I-12). The next antecedent relates to the (potential) **opportunistic behavior of meta-platforms**. To illustrate this, an interviewee (I-05) commented: "…that the [meta-] platform should not have that privilege of seeing what the data is…or selling data that belongs to one marketplace to another marketplace or things like that." Another interviewee (I-03) expressed: "I am not sure about a middleman [a meta-platform] already. I think, when it comes to data, it should be as transparent as possible." Data sovereignty concerns are also caused by the **unclear division of roles and responsibilities** between a meta-platform and data marketplaces. Without this clarity, control exercises remain ambiguous. For example, one interviewee (I-12) said: "It is definitely tough… Who is responsible for providing proof that the data is secure, that you know the data is of quality, that you know the data ownership is correct?"

In the *data ownership and access* domain, **data policy divergence** triggers data sovereignty concerns. A meta-platform commonly aims to be interoperable across data marketplaces in different countries or industries. Nevertheless, different work rules depend on specific areas (I-01), and the translation of diverse legal instruments between countries is difficult (I-02, I-08). For example, in extreme cases where a meta-platform is interoperable with data marketplaces outside the European Union, some regulations like the General Data Protection Regulation (GDPR) may not be applicable (I-01). Hence, data consumers may face difficulties understanding what they can (and cannot) do with the data (I-13). Subsequently, **data type variations** cause complexity to exercise control. In some cases, data consumers may only want to buy a one-off set of datasets (I-03), whereas the others want to go beyond it (I-05), such as purchasing data streams (I-03). Data requirements like latency and time restrictions may apply (I-03). Because different data types require different treatments, providing suitable control access to safeguard all data types is challenging.

Vague data ownership definitions also cause data sovereignty concerns. For example, one participant (I-10) stated: "What happens to the ownership of the data? Is the ownership transferred to the platform, or is it kept? Is it still owned by the data provider?" Likewise, business data sharing **use cases are less clearly defined** when data assets are advertised via meta-platforms. For example, one interviewee illustrated (I-03): "… I am selling these details, and I do not know why I am selling them." Hence, data usage use cases (recorded in a contract) are often unclear and contain insufficient details. Specific details such as data licensing agreements are also frequently ambiguous (I-13). Moreover, creating clear use cases is complex because more parties are now involved (I-03).

We also identified antecedents in the *data usage domain,* where **data provenance difficulties** are one of the principal causes. Generally, meta-platform characteristics allow providers to share their business data to multiple data marketplaces. Hence, data lineage from data providers to consumers becomes complex because two separate entities exist. One interviewee (I-12) mentioned: "Who is responsible for providing the linage from supplier to buyer if you have two stops, which are two separate entities?... We have two parts in the chain." Therefore, there is a possibility of blind spots in the data lineage in a meta-platform (I-7). Subsequently, data

providers may need to **withdraw data** due to specific reasons. For instance, the end-users (or individual data subjects) want to change the consent and remove their data. Nevertheless, it is not easy to retrieve data when it has been shared. Data providers need to identify which data marketplace sells their data (and to which data consumers) (I-09). Finally, another reason for data control loss is **unverified data consumers.** Potential consumers are registered with specific marketplaces, but the nature of onboarding processes is different (I-12). A marketplace may apply a tight certification, while others do not. Therefore, the possibility of engaging with unethical organizations in specific data marketplaces (or countries) exists (I-07).

Related to the consequences, many participants mentioned **knowledge spillovers to competitors.** Sharing data via a meta-platform can be an endeavor to reach unlimited data consumers from many marketplaces (I-09). Nevertheless, many potential data consumers are competitors, which may benefit from the shared data in unanticipated ways (I-01, I-15, I-19). Competitors can go "…somewhere playing around with our data set to know what is going on" (I-13). Hence, commercial secrets may also be exposed (I-19). Another consequence concerns **legal liabilities.** Losing control over data can make providers liable for violating the EU privacy rules (I-11) such as the GDPR (I-09). Therefore, there will be legal action and consequences (I-18), such as having a dispute (I-01) or paying for the damages (I-13). Interestingly, one interviewee (I-13) mentioned the provider's unfortunate situation, especially if they are big companies: "It is the bigger player in the market that's always going to then bear the brunt of it."

Data investment loss also becomes a primary consequence because data consumers may resell the shared data (I-01, I-03, I-16). One participant (I-19) illustrated: "How do you ensure that they do not just resell it to someone else?" In all, the shared data assets can be freely available to everyone (I-02). Finally, some participants expressed concerns about **reputational damage** (I-01) due to, for example, bad press (I-13) so that people discuss unwanted accidents in the public media like radio (I-02). One participant (I-18) commented: "So the consequences can be really, really huge… it can dramatically damage the reputation of the company..."

5 Discussion and Conclusion

This paper explores the antecedents and consequences of data sovereignty in a meta-platform for data marketplaces. Our findings suggest that the meta-platform characteristics play a significant role in amplifying data sovereignty concerns. Compared to the previously known antecedents in the data marketplace context (see Subsection 2.1), we find three distinctive antecedents (classified in the data governance mode category) in the meta-platform context: a) unclear division of roles and responsibilities between meta-platforms and participating marketplaces, b) opportunistic behavior of meta-platforms, and c) untrustworthy data marketplace participants.

These antecedents emerge because a meta-platform is a newly born entity that aims to federate existing data marketplaces. Nevertheless, knowledge about the interactions and proper institution arrangements between these entities is generally unexplored. For example, meta-platforms may have sufficient power to dictate enabling technologies and infrastructures if they are horizontally integrated by the same parent company (such as Alipay, WeChat, or Tencent) (Coe & Yang, 2022; Zhang & Williamson, 2021). Nonetheless, meta-platforms for business data sharing often emerge from consortium efforts (Floetgen et al., 2021). Hence, having a consensus on governance mechanisms and joint efforts to develop technological standards is challenging (Gelhaar & Otto, 2020). Each data marketplace participant may have internal (technically enforced) governance mechanisms to ensure data sovereignty (Lis & Otto, 2020), but such mechanisms may be incompatible with others (Abbas et al., 2021). Consequently, meta-platforms may behave opportunistically if they can access all traffic data across marketplaces (Lee et al., 2017). For instance, they may expensively charge low-bargaining participating data marketplaces to get forwarded traffics. In addition, another unexplored issue relates to the feasibility of technical integration for data marketplace interoperability. To tackle this issue, initiatives such as the International Data Spaces Association explore REST API-based Dataspace Connector[5] to find potential ways to make this vision a reality.

[5] https://international-data-spaces-association.github.io/DataspaceConnector/ accessed on May 13, 2022

Some antecedents tend to be more complicated (to mitigate) in our new context because meta-platforms enable data asset movement across multiple marketplaces. As indicated in Section 4, for example, data provenance becomes more difficult because we now have two separate entities, making the probability of having blind spots in the data lineage amplifying. Thus, data providers generally do not know what happens when data is transferred. Blockchain-based smart contracts are one of the (future) promising means for data provenance (Moyano et al., 2021), but these may be incompatible with other marketplaces. Although interoperable means such as "side-chain" (or "interchain") are essential due to the nature of meta-platforms that federate existing data marketplace, this initiative is generally still in its infancy (Singh et al., 2020).

We identify four main consequences of data sovereignty: knowledge spillovers to competitors, legal liabilities, data investment loss, and reputational damage. These findings implicitly indicate why data providers fear losing control over their data. Therefore, similar to the previous findings from the extant literature on data marketplaces (cf. Agahari, 2020, 2021; Spiekermann, 2019), we may confirm the inheritance of (and argue that) data sovereignty concerns also negatively influence providers' willingness to engage with business data sharing via a meta-platform. Nevertheless, our proposition is still a "working hypothesis," and further confirmation is needed (see Casula et al., 2021).

We suggest four future research areas considering our research constraints. First, the unit of analysis of this study focuses on the data providers. Future work can explore the data consumers' perspectives to balance the standpoint. Secondly, we focus on a use case of meta-platforms. In other scenarios, data providers may have already registered in a particular market before joining a meta-platform. Exploring more situations can help to provide more affluent antecedents. Subsequently, our interviewees did not experience using meta-platforms for data marketplaces in practice—because many related initiatives are in the development phase, and they engaged with Minimum Viable Products (MVPs) instead. Nonetheless, this work is (part of) and in line with a new IS paradigm so-called "speculative engagement" (Hovorka & Peter, 2021a, 2021b): preparing for the future by speculatively theorizing the upcoming scenarios. Hence, we recommend repeating the exercise with a case study approach to verify our working hypothesis. Finally, given the nature of our qualitative approach, our study cannot be used to generalize to specific

populations. Instead, at this stage, we offer a pre-conceptualization of data sovereignty that is more suitable for developing theoretical propositions (Yin, 2018). Therefore, we call for a deductive approach to confirm our findings in future research.

Our study theoretically contributes to the existing IS digital platform literature, particularly in a research stream related to multiplatform ecosystems (with a specific emerging topic that correlates meta-platforms, data marketplaces, and data sovereignty). We are among the first who conduct an empirical investigation of this topic, thus providing an early conceptualization of antecedents and consequences of data sovereignty concerns in meta-platforms for data marketplaces. In doing so, we provide the stepping stones to theorize data sovereignty in this context. These identified antecedents can also be a basis for developing design requirements for designing (future) solutions, which are common in the Design Science Research approach (Peffers et al., 2007). Future work will explore governance mechanisms to tackle data sovereignty in this meta-platform (see our future planning at Abbas, 2021). Our study also highlights how the meta-platform context plays a pivotal role in distinguishing (and amplifying) data sovereignty concerns in the previously known data marketplaces, especially for the antecedents in the data governance mode category. Further research can also examine other concerns beyond data sovereignty (e.g., business model challenges related to meta-platform viability).

Practitioners can reflect on our identified antecedents to help providers ensure data sovereignty. Specifically, these antecedents can serve as a baseline for future specific works, such as building a threat model. Moreover, policymakers can reflect on this finding to work on macro-areas, such as policy divergence across the EU and legal protection for data assets. We hope a meta-platform can be one distinguished instrument to fulfill what we are optimistic for in a Data Economy: a single European Data Market in 2030.

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Self-Efficacy Improves UTAUT to Describe Adoption of Health-Enhancing Physical Activity Programs

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Abstract There is consensus in health studies that regular physical activities of sufficient intensity and duration contribute to better health both in the short and long term. In an ongoing research program, we focus on getting young elderly, the 60-75 years age group, to adopt and include physical activities as part of their everyday routines. Regular health-enhancing physical activities can serve as preventive health care, which will improve and sustain quality of life and build up savings in health-care macro costs for an ageing population. We have learned that digital service tools can be instrumental for the adoption and use of activity programs, and that the Unified Theory of Acceptance and Use of Technology (UTAUT) is instrumental for the acceptance and use of digital tools and services. We will argue that the UTAUT is not sufficient as such but can be enhanced to describe the adoption and use of health-enhancing physical activity programs.

Keywords: physical activities, young elderly, digital service tools, UTAUT, self-efficacy, HEPA.

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1 Introduction

We work out a theory framework for the adoption and use of HEPA programs among young elderly with the guidance and support of digital tools for logging physical activity. HEPA is an acronym for *health enhancing physical activity*, which translates to physical activity (PA) of enough intensity and duration to give short- and long-term health effects. A HEPA program consists of one or several physical activities that will give health effects when carried out over some period (typically, weekly programs adopted and used for several months); the combinations of PAs to programs work out individual PA characteristics and how well they combine (PAs may be conflicting or supportive); well-balanced, effective, and enjoyable combinations of PAs form the basis for HEPA programs.

Health recommendations agree on that regular PA at moderate intensity for at least 150 minutes per week will have positive health effects (cf. [34]). The European HEPA network offered some guidelines (in 2000): "health-enhancing physical activity is any form of physical activity that benefits health and functional capacity without undue harm or risk". The guidelines state that "physical activity does not need to be strenuous to be effective. Thirty minutes a day of moderate-intensity activity is enough to benefit health". These guidelines may be too general and not effective enough for HEPA programs (cf. [19], [24]).

Our context is the young elderly – the age group 60-75 years – which public policy more or less has ignored – "*we are too healthy*, *to active*, *with too good social networks to need any intervention or support from public resources*"; and "*we are too many*", a sarcastic interpretation of prevailing political opinions. Nevertheless, young elderly should be given some priority - HEPA programs would offer long-term effects in cumulative health and social care costs; even a few percentage points in cumulative savings will be significant in actual numbers – in Finland, the young elderly group is 1.3 million and the annual health care costs for this group was 3.7 B€ in 2019 according to the Finnish Institute for Health and Welfare.

A renowned physician, himself part of the young elderly age group, has found that – if you adopt and continue with systematic HEPA programs when you turn 60, then you get 10 more good senior years. This insight gains support from a large number of research programs (for example, [4], [34]). Nevertheless, the insight has

not turned into action programs; the ATH 2010-2017 study in Finland (ATH, 2019 [13], [14]) shows that in the age group 55-74 years only 15% spent several hours per week in PA-programs; in the 75+ age group we are down to 7%.

The pensioners organizations are aware of the problem and the challenges; they develop and run PA programs among and for their members. We learned that most offered PA programs, (i) are not intensive enough, (ii) are not running for enough time, and (iii) are not regular and interesting enough to become sustainable habits for young elderly. The policy is that the programs should "fit every-body", which requires that they be adapted to the participants that have spent least time with physical activity and exercise. The complaints get young elderly to drop out of the organized activities. Thus, we should find some better way to get them to adopt and sustain physical activities and exercise.

The "better way" is the *DigitalWells* (short for *Digital Wellness Services for Young Elderly*) research program 2019-22 that recruited more than 800 participants from the pensioners organizations (and 200 more participants from other organizations). We developed digital service tools to support the participants with building and monitoring weekly programs. The tools also collect daily data on actual PA exercises, which is combined with data from follow-up surveys (collected with other digital service tools in 6-month intervals) on perceptions of how effective participants believe their exercises are. Data is collected in cloud-supported databases for analysis - both cross-sectional and longitudinal - to answer research questions in series of studies (cf. [18], [20], [23], [32]); here we will summarize some of the results and further develop a couple of research questions.

In *DigitalWells* we want to find drivers that could get young elderly (i) to adopt and use HEPA programs (RQ1) when aided by digital service tools, and (ii) to sustain the adoption of HEPA programs (RQ2).

In Information Systems research the first choice for a theory framework would be the UTAUT (cf. [36]), as we assume that the HEPA adoption and use can be aided by digital service tools. The UTAUT describes the acceptance and intention to use digital service tools, but it is doubtful if it can describe the adoption and use of HEPA programs. Venkatesh [37] refers to his framework as the UTAUT paradigm for acceptance and use of technology; a paradigm (cf. [10]) is normative, rigid and

guides research to get valid and verifiable results; Venkatesh [37] is not paradigmatically restrictive but recommends adding constructs to the UTAUT as needed. Then our agenda is to find out if we can improve on the UTAUT to find answers to RQ1 and RQ2.

Section 2 is a short introduction to the methodology used, in section 3 we summarize some results from studies carried out in *DigitalWells* with the UTAUT framework and compare them with several similar studies collected by Venkatesh et al [37]. Section 4 introduces Self-efficacy for Exercise as an alternative framework, which is tested with an empirical study that is summarized in section 5. Section 6 offers an outline of how self-efficacy combined with ELM (the Elaboration Likelihood Model) can improve on UTAUT to describe the adoption, use and sustained adoption of HEPA programs. Section 7 is a short summary, conclusions, and an outline of the next steps in the research process.

2 Methodology

The *DigitalWells* research and development program has been running 2019-22. It was initiated in cooperation with three pensioners organizations with 350 000 members that helped recruit volunteers for the program; *DigitalWells* collected 30 groups (with 25-25 members per group) and more than 200 participants from other organizations. Most participants spent 18-30 months with the program. The research design adapted to the objective of being a development program that that would attract and support participants to get active with PA exercise, to combine exercises to (weekly) PA programs and gradually develop the activities to (weekly) HEPA programs. No attempt was made to make random selections of the participants for the groups nor to build control groups that would not use the *DigitalWells* technology and support; the aim was to get as many young elderly participants as possible active with PA and then to sample the groups for the research program.

DigitalWells developed a PA logger application for smart mobile phones (Android, iOS) that was integrated to a (cloud-based) database infrastructure and later also synchronized with (Android, iOS) sport watches. The PA logger supported the participants with registering PA exercises, the intensity and duration of the exercises, built up a PA history for the participants and offered them (weekly, monthly, 6

monthly, yearly) reports on their PA programs with both numerical and graphical follow-ups.

The participants had a selection of 35 PA exercises (later expanded to 48 exercises) to choose from; each PA exercise was graded in terms of CPA-MET (cf. [40]) as *light*, *moderate*, *vigorous* and the effort spent in MET-min. A standard requirement for HEPA exercise is to reach 675 MET-min/week (cf. [14]) but there are some variations from this requirement for gender, age-group, PA history, etc. Follow-up studies showed that 96% of the participants reached HEPA levels after 3-4 months in the program. A large majority of the participants were active with 5-6 common PA exercises; the participants logged 294 140 PA exercise events over the program, which built a large database of actual PA efforts. All participants were registered with 8-number pseudonyms and had given written consent to having the data collected with the PA logger registered in the database (the local ethical committee deemed that no separate approval was required for the conducted studies).

Postdoc researchers worked with the participating groups as field researchers to initialize PA programs, to set up and support the use of the PA logger, the smartphone platform, the synchronization with the cloud-supported database and smartwatches, and to carry out follow-up studies. The field researchers worked first locally with the groups but after the covid-19 restrictions were applied all activities went digital. This offered some challenges for the participants, but follow-up studies showed that 91% of them could carry out all parts of the program.

Follow-up studies were carried out after 4, 6, 12, 18 and 24 months in the program with *LimeSurvey* using the participants' smartphones; this turned out to be an efficient and smoothly running setup. The surveys work with theory frameworks from UTAUT, IPAQ(E) and Self-efficacy for Exercise, the questionnaires built on self-reported assessments of how effective PA exercises are and of the factors that form the drivers in the theory frameworks. The judgments of the effectiveness of the PA exercises are followed up with the actual PAs for each participant (as registered with the MET-min/week (month, 6 months)); these were first self-reported and manually inserted in the PA logger, later they were also registered with cardio load from sport watches that were synchronized with the PA logger. The samples built up for the follow-up studies were sufficiently large and the data was analyzed with a selection

of standard models using SPSS 26 software: partial least square structural equations, multifactor analysis of variance, Wilcoxon signed-rank test, Mood's median test, etc.

The overall goal was to test the UTAUT conceptual framework with supporting, synergistic concepts to add analytical capabilities to the UTAUT. This approach has been used by Brown et al. [6] and Lallmahomed et al. [21], and we will try it out.

3 Results and Insight with the UTAUT Framework

The young elderly in the *DigitalWells* research program participated in a number of studies that have been published; here we will collect only a few results that are part of our storyline for answering RQ1 and RQ2. Makkonen et al. [23] noticed that there are rather few studies of digital wellness technologies among the young elderly, which makes it difficult to compare and cross-validate more general research results. They focused on PA logger applications, mobile phone applications that allow users to log, keep track of and get updates on their PA exercises. The study builds on a sample of 115 young elderly who used a PA logger to follow up on their weekly PA exercises; daily activity data was analyzed with partial least square structural equation modelling (PLS-SEM) using UTAUT2 as the research model (cf. [36]). Makkonen [23] found five of seven UTAUT constructs to be relevant (all participants had the same resource requirement, got the same training and support (no difference in facilitating conditions) and the application was free (no price value)) (cf. [36]). *Performance expectancy*, *hedonic motivation*, and *habit* were found to have positive and statistically significant effects on behavioral intention to adopt and use the PA logger; *habit* proved to be the primary construct. The results differ from previous studies (e.g., Yuan et al. [39]; Macedo [22]; Duarte and Pinho [11]) which typically bring out performance expectancy as primary construct. Talukder et al. [33] show a similar result, that habit is the strongest driver on use intention for wearable fitness devices. The study [23] follows a standard approach for studies based on the UTAUT framework (cf. [37]) and finds similarities and support among previous studies.

In two other studies [24], [25] Makkonen et al. focus on the adoption and use of digital wellness technologies and how the use evolves after an initial acceptance. This type of longitudinal study is important as it captures "lapses" in the intention to use and shows that the UTAUT constructs are not constant over time but change and

evolve (cf. Epstein et al. [12]). The studies collected PA logger data in three subsequent surveys, after about four months (T1), 12 months (T2) and 18 months (T3) of using a digital PA logger; a final sample of 91 participants was used as they responded to the survey at all three time points. The study used UTAUT2 (cf. [36], [37]) as the theoretical framework and two constructs - *hedonic motivation* and *habit* - had positive and statistically significant effects on the acceptance and use of the logger; *performance expectancy* had a positive and statistically significant effect at T1 and T3, but not at T2; *effort expectancy* had a positive and statistically significant effect at T2, but not at T1 and T3. The proportion of explained variance (R2) in behavioral intention was 73.2 % at T1, 77.0 % at T2 and 83.0 % at T3, which shows that the constructs capture behavioral intention quite well.

The results are interesting. First, the construct scores stabilized over time. Second, the scores declined quite strongly between T1 and T2, but less so between T2 and T3. A likely explanation is the novelty effect, where the PA logger first is perceived favorably but then more realistically with continued use; the longer the PA logger was used, the more effortful and less fun it was found; this shows in the scores for habit that declined strongly also between T2 and T3.

It appears that the UTAUT2 constructs for which there are statistical support – habit, hedonic motivation, performance expectancy and effort expectancy – explain intention to use a PA logger but not necessarily to adopt and use HEPA programs. It is of course plausible that once a PA logger is accepted with an intention to use it, the user starts PA exercises and may adopt HEPA programs. This type of cross-context influences is found as UTAUT extensions (cf. [37], Table 2 for a list of 37 studies).

Venkatesh et al [37] list several key hypotheses for extensions of the UTAUT framework (cf. [37], Appendix D); they also list hypotheses on factors that will not have a significant influence on behavioral intention: facilitating conditions, computer self-efficacy, computer anxiety and attitude toward using technology. Computer self-efficacy - the confidence a user has in his/her ability/competence to use a computer - is getting a minor role in the 2020's as smart mobile phone technology becomes a dominant platform – also among young elderly.

Nevertheless, *self-efficacy* is an interesting theory framework for drivers that could offer answers to RQ1 and RQ2. Self-efficacy is also attractive because there is some experience in combining it with the UTAUT framework (cf. [37]).

4 Self-efficacy and HEPA Programs

We will next explore self-efficacy and the possibilities it can offer as a conceptual framework for the work on HEPA programs. Bandura [3] shows that self-efficacy beliefs affect the quality of human functioning through cognitive, motivational, affective, and decisional processes. He further finds that self-efficacy beliefs influence how well people motivate themselves and win over difficulties through the goals they set for themselves, their outcome expectations, and causal attributions for successes and failures. This fits quite well an intuitive understanding of what is needed to start, continue, and then sustain the use of HEPA programs.

Bandura (cf. [1], [2], [3], [28]) introduced self-efficacy as "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" [2], or shorter "the belief that one can achieve what one sets out to do" [1]. The sources of self-efficacy are developed in four ways [3], through (i) *mastery experiences* (if people have only easy successes, they come to expect quick results and are easily discouraged by setbacks and failures; resilience is built by learning how to manage failure); (ii) *social modelling* (seeing people similar to oneself succeed by perseverant effort raises aspirations and beliefs in own capabilities); (iii) *social persuasion* (people who are persuaded to believe in themselves are more perseverant; individuals are encouraged to measure success by self-improvement); (iv) people rely on their *physical and emotional states* in judging their self-efficacy. There are several variations of the influences of self-efficacy (cf. [28]) since the first version was introduced in 1977.

Kari et al [20] studied how effective a digital PA application is in promoting self-efficacy for physical activity in several groups of young elderly that had been 12 months or more with the *DigitalWells* program. The study traced changes in self-efficacy, at T0, T1(+4 months) and T2 (+12 months) with online surveys and the Self-Efficacy for Exercise (SEE) Scale [52], a self-report instrument that has been tested also with older adults [31]. A participant assesses his/her ability to exercise for 20 minutes three times per week and reports his/her personal confidence on a [0, 10] scale relative to nine statements on obstacles; overall self-efficacy (TS [0, 90])

is the sum of the nine statement measures. The statistical significance of the changes was analyzed with the Wilcoxon signed-rank test [70]; the changes in self-efficacy were measured at both item and construct level.

As Kari et al [20] carried out the study 264 participants formed the initial group; 165 participants responded to all three self-efficacy questionnaires and formed the sample. At the construct level, the total score (TS) showed a statistically significant change both T0-T1 and T0-T2; the mean total score had increased from 56.0 (T0) to 62.0 (T1) and 61.5 (T2). The changes in self-efficacy were positive after 4 months and sustained at after 12 months. At the item level, three (of 9) items showed statistically significant changes both T0-T1 and T0-T2; four items statistically significant changes T0-T1 but not T0- T2 (all changes were positive, the mean score had improved). *Mastery experience* (cf. [2]) was the main explanation for increased self-efficacy. The PA application enables and supports self-tracking of PA exercises and offers graphical reports of collected PA data to allow users to verify that they have mastered chosen and started PA exercises.

In [20] Kari et al found that the total score (TS) for self-efficacy first increased and was sustained after 12 months. The increase is important for sustained PA (e.g., [26], [27], [38]) and for sustained HEPA when that is reached. The results are in line with earlier studies (e.g., [9], [15]).

Sustained self-efficacy improvement supports sustained adoption of PA exercise, which contributes to health benefits; when HEPA levels are reached it is reasonable that sustained improvement secures long-term health effects (needs to be verified in future research). Self-efficacy may not increase indefinitely, mastering PA exercises and a PA application will typically be accomplished in 1-2 moths (cf. [24], [25]) and the increase in self-efficacy will wear off, but self-efficacy is a possible driver for sustained adoption of HEPA programs among young elderly.

Bandura [3] states ([3], p. 15) that "efficacy scales are unipolar, ranging from zero to a maximum strength of belief; a statement of intention should not be included in a self-efficacy scale". This contrasts with the UTAUT which ends with "behavioral intention" (cf. [36]) but could be useful for the extension (cf. [37]) which ends with the actual use. Testing for self-efficacy should be done with controlled experimentation and self-efficacy should be raised or lowered by non-performance

means (cf. [2]); the stronger the self-efficacy among test subjects, the more demanding goals they set for themselves, the more effort they spend and the better performance they manage. Self-efficacy is positively related to subsequent performance after controlling for past performance, a positive contribution of self-efficacy to subsequent performance not only increases over time but is a stronger predictor than past performance at each of the time points (cf. [2]).

5 Empirical Tests of Self-efficacy and PA Exercise

Bandura (cf. [1], p 207) states that "the intensity and persistence of effort, and hence level of performance, should be higher with strong than with weak self-efficacy". Thus, high self-efficacy should match high levels of PA exercise, increases in self-efficacy should match increases in PA exercise; thus, by building high levels of self-efficacy for exercise among young elderly we could build a basis for high and sustained levels of HEPA exercise.

With the group of 264 participants in [20] we carried out a first screening of how well the participants reached 675 MET-min/week, which is a simple HEPA standard. The initial check was at T0, follow-up 1 at T1 (+4 months), follow-up 2 at T2 (+12 months) and follow-up 3 at T3 (+18 months); not all participants answered the questionnaire at the later follow-ups.

675 MET-min/week	Initial	Follow-up 1	Follow-up 2	Follow-up 3
N	238	192	181	147
Percentage	91.9	97.5	97.8	96.7

The PA exercise efforts decline at the third follow-up. We checked the changes in self-efficacy T0-T1 and T1-T2 (data for the self-efficacy check at T3 is not yet ready) to find out if there are matches with the changes in PA exercise T0-T1 and T1-T2.

The 165 participants who responded to the self-efficacy study at T0, T1 and T2 formed the sample for the present study. Following Bandura (cf. [3]) we used the following control variables (simplified from the original sample to build larger groups): (i) agegroup ($\leq$ 69 years; $\geq$ 70 years); (ii) gender (male; female); (iii) education (4 levels); (iv) used apps ($<$ 3 years; 3-5 years; 6-10 years; $>$ 10 years); (v) BMI (normal; overweight; obese); (vi) residential environment (5 categories).

A multifactor analysis of variance was used to find effects of the control variables on the difference variables (main effect model: MET0-MET1, MET1-MET2 and SE0-SE1, SE1-SE2). The METi is the total MET-min per week summed at T0, T1 and T2; the SEi is the self-efficacy total score summed at T0, T1 and T2. Changes in self-efficacy and actual MET-minutes were calculated as difference variables T0-T1, and T1-T2. Bonferroni adjustments for multiple comparisons were used for pairwise comparisons. The statistical test is significant if the p-value is ≤ 0.05. The analysis was carried out with the SPSS 26 software.

For MET0-MET1 there were three statistically significant factors: education ($p = 0.009$), BMI ($p = 0.018$) and residential environment ($p = 0.027$); the increase T0-T1 is larger in the university education group compared to the vocational education group; the increase T0-T1 is smaller in the obese group compared to the normal weight ($P = 0.30$) and the overweight ($p = 021$) groups; the increase T0-T1 is larger in the big city group compared to the small or medium-sized city ($p = 0.020$) and the countryside ($p = 0.042$) groups; for MET1-MET2 there were no statistically significant factors.

For SE0-SE1 there were no statistically significant factors; for SE1-SE2 gender is a statistically significant factor – the increase T1-T2 is larger in the male than in the female group. Kari et al [20] found that the self-efficacy total score had stabilized by T2 for the whole group, which means that there probably is a decline in the female group. The experience of using applications on smartphones (used apps (< 3 years; 3-5 years; 6-10 years; > 10 years)) was not a statistically significant factor for changes in neither self-efficacy nor PA exercise; the users' experience with both smartphones and applications are often mentioned as problems for the use of digital PA loggers (cf. [11], [15], [22]).

The present research design did not show the expected relation between positive changes in self-efficacy and PA exercise, which could have formed a basis for a more detailed analysis of the joint drivers.

6 Self-efficacy and ELM as UTAUT Extensions

The UTAUT2 served as a framework in several of the empirical studies summarized in section 3; the UTAUT2 is a relevant framework for study of acceptance of digital services like the PA logger (cf. also Yuan et al. [39]). We expressed some doubt that drivers that motivate young elderly users to accept and use the PA logger also make them adopt and use HEPA programs; here we found use for the Elaboration Likelihood Model (ELM).

The ELM was constructed by Petty et al. [29], (i) to work out influence processes and their impact on human perceptions and behavior, and (ii) to explain why a given influence process may have varying outcomes across different users in each context. Influence processes can contribute to either *intrinsic* or *extrinsic* motivations and help build inherent satisfaction or instrumental outcomes that could motivate HEPA programs. The key part would be how an influence process is used to motivate young elderly. It appears that with a larger group we need a series of influence processes (one process never fits all). The task would be to tailor influence processes for young elderly to get them interested in and to adopt HEPA programs; then to get them to move to sustained use of the programs.

The ELM has been used as a theory framework to describe and explain intention to use information technology (IT) (cf. [5]). The ELM logic appears to have some common ground with the UTAUT, and we have sketched out a joint conceptual framework. The ELM part includes self-efficacy as a driver and works out how PA (program) users (here, young elderly) adopt and accept sustained use of HEPA programs. The UTAUT part works out drivers for intention and then actual use (cf. [37]) of the PA logger to facilitate PA exercises and use of HEPA programs.

In ELM attitude is the key influence (cf. [5]) with moderating factors that include perceived useful-ness, source credibility and argument quality (a function of source credibility); self-efficacy (job relevance in ELM for IT) and user PA history (user experience in ELM for IT) are added as moderating factors. In fig.1 perceived usefulness is now a driver for both the PA logger and the sustained use of HEPA programs and will (i) support logging of PA exercises, (ii) evaluate PA exercises with HEPA criteria, (iii) help organize PAs in PA programs, (iv) support goal setting for PA programs and (v) guide and support the choice of PAs for HEPA programs.

In terms of the ELM (cf. fig.1), perceived usefulness and attitudes to HEPA programs are intrinsic motivations for sustained use of the programs; more perceived usefulness strengthens attitudes (and vice versa). One of the early studies (cf. [23]) showed that performance expectancy, hedonic motivation and habit have statistically significant effects on behavioral intention to use a PA logger. These UTAUT constructs (cf. [37]) have some kinship with the ELM constructs for HEPA programs: performance expectancy (~ perceived usefulness), hedonic motivation (~ attitudes), habit (~ sustained use). In [16] demographic backgrounds do not decide the effectiveness of the PA logger, but previous PA experience can be more decisive (~ user PA history). In [17] participants fall in three categories – low, moderate, and high-level PA activists (~ user PA history) – who have different attitudes to PA exercise (and hence to HEPA programs). Self-efficacy – and sustained self-efficacy improvement – is a function of mastery experiences, social modelling, social persuasion, and physical and emotional states (cf. [3]); self-efficacy contributes to attitudes to HEPA programs and help form the sustained use of HEPA programs; the self-efficacy drivers are not included among the UTAUT drivers.

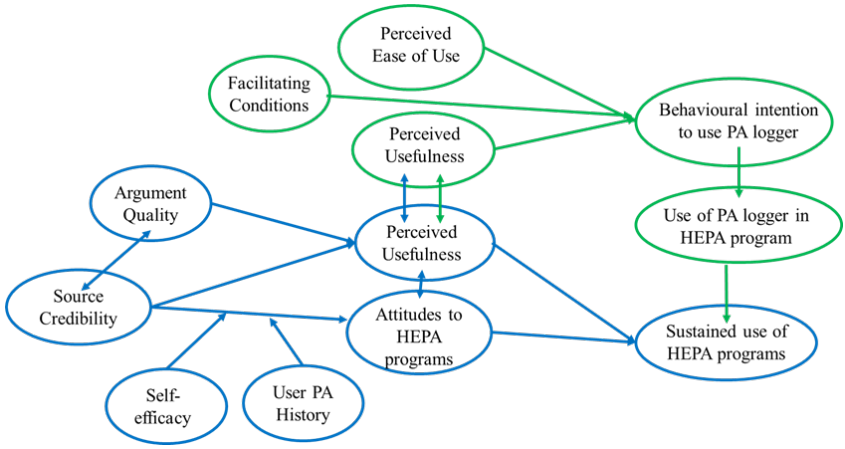


Figure 1: The ELM (blue) + UTAUT (green) framework applied to the sustained use of HEPA programs

The attitudes to HEPA programs build on getting better and sustained health effects; "*to get more good years*". Argument quality and source quality build on verifiable medical research results to show that HEPA gives health effects, both in the short- and long term.

The users recruited for the *DigitalWells* program represent three main categories, which are expansions on user PA history, (i.1) regular PA users, who have been active for multiple years (even decades), (i.2) sporadic PA users who are active in an on-off mode, and (i.3) inactive PA users with on-off intentions to get active. The three categories show different attitudes to involvement with HEPA programs that require sustained and more demanding efforts. Self-efficacy brings out reasons to build mastery of HEPA programs, deciding on goals, (ii.1) to lose weight and get in (much) better shape, (ii.2) to stay in sufficiently good shape to be able to carry out daily tasks, but also (ii.3) to enjoy life and (social) pleasures without HEPA pressures, or (ii.4) to relax in retirement with no HEPA demands; the mastery could obviously cover both being active with and staying out of HEPA programs.

We propose that the PA logger will contribute to a sustained use of HEPA programs; for this we need only three of the UTAUT drivers for behavioral intention, (ELM will cover the rest of the drivers): (i) perceived usefulness (≈ performance expectancy); (ii) perceived ease of use (≈ effort expectancy) and (iii) facilitating conditions. The facilitating conditions are determined by the context and include (cf. [37]) digital experience, trust, and technology readiness.

Fig.1 now sketches out how the conceptual frameworks of ELM and UTAUT could combine to give a meaningful description of how our focus group adopts, uses and sustains the use of PA programs, with an intention to make progress towards HEPA programs, through the adoption and use of the digital PA logger, that could be part of a system of digital services {DS} that offer (for instance) coaching, gaming, evaluation of PA exercises with HEPA criteria, peer group interactions, (friendly) competition, etc. The extended {DS} system with the PA logger supports the adoption and use of PA programs, will support the progress to and sustain the use of HEPA programs for extended periods of time; details will be worked out in some next steps.

In the ELM framework we work out the usefulness of HEPA programs from attitudes to sustained HEPA, and the self-efficacy and history of individual HEPA/PA for a user. In the UTAUT framework we work out what digital services will be useful and if and how they are easy to use for sustained use of HEPA programs. This approach, to use synergistic combinations of conceptual frameworks was used by Brown et al. [6] and Lallmahomed et al. [21], and offers possibilities to

work out innovative, new models for description and explanation that are not available and verifiable with the original conceptual frameworks.

7 Summary and Conclusions

Physical wellness comes from physical exercise to build stamina, muscle strength and balance, and to ward off age-related serious illness; sustained physical exercise helps to meet everyday requirements. Studies show (cf. Wallén et al [34]) that systematic PA contributes to good quality of life in senior years. The understanding of why physical exercise matters comes from the young elderly themselves (cf. [7], [8]): "*it is nicer to get old if you are in good shape*" or a more sober version: "*to get good remaining years*". These insights also capture a strong motivation to get in better physical shape.

We found it doubtful that drivers that get young elderly to accept and use digital tools also make them adopt HEPA programs, i.e., UTAUT is not sufficient as a theory framework. We propose to use a combination of Self-efficacy for Exercise, ELM and UTAUT to better describe adoption and use of HEPA programs and to propose that the use will be sustained with support from digital services. Using synergistic combinations of theory frameworks shows that the UTAUT can be improved with this approach, which then will have implications for enhanced use of the UTAUT framework in new, and so far, untried applications (following Venkatesh [37]). We further propose that the drivers we are searching for point to explanatory theories (in the sense of Popper [30]) that explain the sustained adoption and use of HEPA programs when the UTAUT framework identifies and describes useful digital service support.

The answers to RQ1 and RQ2 are already apparent in the text but will be summarized as follows:

- RQ1. What drivers could get young elderly users to adopt and use HEPA programs when aided by digital service tools? *Intrinsic motivations supported by extrinsic motivations, i.e. - expected inherent satisfaction supported by performance accomplishment, health goals and objectives* ["more good years"]
- RQ2. What drivers could sustain the adoption of HEPA programs? *Intrinsic motivations supported with progress in self-efficacy, i.e. - perceived usefulness, attitudes to HEPA programs supported with (progress in) self-efficacy (mastery experiences) with*

HEPA combined with ease of use, perceived usefulness of, and facilitation from digital service support.

Forthcoming research will explore what drivers are necessary and/or sufficient to get sustained adoption and use of HEPA programs with different types of user groups (male/female, age group, PA history, HEPA relevance, HEPA goals and HEPA programs) and in various contexts (HEPA individually, HEPA with friends, HEPA in organized groups, HEPA with personal/group coaching, HEPA with digital coaching, public (standard) HEPA programs, etc.).

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More Than One Way to Solve the Healthcare Innovation Crisis With Digital Platforms. Various Forms of Platform Openness Impacting Primary Healthcare

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Abstract Whereas open digital platforms drive innovation in industries, platforms in primary healthcare are mostly closed. Policy-makers have been looking for ways to open up primary healthcare platforms to stimulate collaboration and innovation and need to do so even more due to the ongoing COVID-19 crisis. Yet, there is not one way of opening up platforms in primary healthcare, just as it is unclear how different ways of openness can lead to more innovation. This paper analyzes the opportunities and challenges in realizing platform openness while examining alternative forms of openness. To answer this, we (1) conceptualize different forms of platform openness (sponsor-provider-platform-user openness), (2) examine how these forms of openness can resolve barriers to innovation, and (3) examine what challenges need to be overcome to realize that form of openness in practice, such as complexity in roles, regulations, and ICT infrastructure. The findings are relevant to structure further research on how platform openness leads to more innovations in healthcare.

Keywords: digital platform platform opennes platform ecosystem innovation healthcare.

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1 Introduction

The COVID-19 crisis has painfully exposed that existing digital platforms fall short in supporting caregivers and patients. When caregivers needed comprehensive and accurate data to diagnose, treat, and identify risk groups, they faced low reliability and information availability (EHRIntelligence, 2020a). Even when patient files were digitalized, caregivers often could not access them due to legal constraints and a lack of openness between heterogeneous platforms (Lenert and McSwain, 2020). These issues also hinder innovation in the healthcare domain. In response, governments are urged to issue temporary emergency laws to improve information exchange between healthcare platforms, like in The Netherlands (Rijksoverheid.nl, 2020) and the U.S. (Anderson, Belcher and Parker, 2020; EHRIntelligence, 2020b). However, these recent events highlight a significant systemic problem: caregivers experience digital platforms as a burden rather than an enabler for innovation and effective healthcare.

A digital platform is an "extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it, and the interfaces through which they interoperate" (Tiwana, Konsynski, & Bush, 2010, p. 675). In healthcare, digital platforms facilitate numerous tasks, including patient-caregiver communication, administrative jobs, and tracking treatments. Various platforms exist in most countries, supplied by multiple parties and IT-departments with complex organizational arrangements (WHO, 2020; Frontoni et al., 2019). Most platforms are highly complex, resulting from years of expansion in information systems, participants, and arrangements (Bygstad and Hanseth, 2018), and offer varying functionalities (Darmon, Sauvant, Staccini and Letrilliart, 2014). Further, most digital platforms in healthcare are organized as closed silos (Bannister, 2001; OECD, 2011), meaning third parties cannot create add-on functionalities. Both scholars and practitioners have stated that, in general, openness in information technology in healthcare, like sharing patient data and add-on functionalities, is limited for technical and non-technical reasons (OECD, 2011). Reasons for this lack of openness include the fragmentation of systems, users, and software suppliers (Bygstad, Hanseth and Le, 2015; Furstenau et al., 2018), and the challenge to deal with non-interoperable legacy systems (Scott Kruse, Karem, Shifflett, Vegi, Ravi and Brooks, 2018; Hermes, Riasanow, Clemons, Böhm and Krcmar, 2020). Also, healthcare-related data's sensitive nature complicates system openness and

information exchange across healthcare platforms (Grisot, 2018). While standards that allow openness are increasingly available (e.g., by shared data transferring protocols such as the interoperability standard HL7FHIR or openEHR), these standards are scarcely adopted in existing systems and platforms (Dixon, Rahurkar and Apathy, 2020; Schreiweis, Pobiruchin, Strotbaum, Suleder, Wiesner and Bergh, 2019). In other industries, digital platforms have largely opened up, driving innovation and information exchange (De Reuver, Sørensen and Basole, 2018). Open platforms are assumed to increase innovation (Boudreau, 2010) and transform business models (Tilson, Lyytinen, & Sørensen, 2010). Therefore, governments may enforce platform openness, similarly as in banking (Schreieck, Wiesche, Kude, Krcmar, 2019). In this article, we explore whether open digital platforms could similarly transform the healthcare industry, allowing (1) third parties to create innovative add-ons to platforms and (2) easier exchange of data to ultimately improve decision making and patient self-management (Joiner and Lusch, 2016). What the openness of digital platforms in healthcare entails is not clear yet. In general, platform openness is the extent to which external parties can use, extend, or commercialize a platform (Benlian et al., 2015; Boudreau and Hagiu, 2009). Platforms can become open to different degrees (West, 2003), towards different roles (Eisenmann et al., 2009), and on different levels (Ondrus et al., 2015). How these levels and forms of openness translate into the specific context of primary healthcare is yet unclear. Furthermore, it is unclear how different forms of platform openness can resolve barriers to innovation and how the forms of openness are realistic to achieve in practice. This paper analyzes the opportunities and challenges in realizing platform openness. Our purpose is to go beyond simplistic representations of platform openness projected on a simplified application domain and develop a comprehensive conceptualization of platform openness and combine this with a representational delineation of the primary care sector. To answer this question, we (1) conceptualize different forms of platform openness in primary healthcare, (2) examine how these forms of openness can resolve barriers to innovation, and (3) examine what challenges need to be overcome to realize that form of openness in practice. The paper is grounded in desk research and interview data gathered in the primary healthcare domain in The Netherlands. The primary care domain concerns all professional care patients can consult without a prescription to the hospital. This domain of care yields tremendous amounts of patient information and is highly dependent on information exchange between

caregivers. The Dutch system provides a suitable setting for several reasons. First, platforms in this domain in the Netherlands already have a mature ICT-infrastructure and well-developed health and information systems relative to other EU countries (Tavares, 2018). All primary caregivers rely on digital platforms. Studying a situation with an advanced platform infrastructure is useful for its findings can yield outcomes applicable to other (unobserved) countries. Moreover, previous studies show that changes in information systems in healthcare have significant consequences for the involved stakeholders, roles, and responsibilities (Grisot et al., 2018). Therefore, it is interesting to study the primary care domain in the Netherlands, which is rich in terms of stakeholders, both public and private, that collectively define how the primary care domain and its platforms are organized. This paper contributes to understanding healthcare innovation through a lens of platform concepts, specifically for primary healthcare. In this way, the paper complements existing insights of platform-driven innovation in healthcare in other domains such as elderly care (Nikayin et al., 2013) and primary prevention (Nikayin et al., 2014). The paper also contributes to digital platform literature by contextualizing the antecedents and consequences of platformization in the specific domain of digital healthcare, thus answering calls from scholars for domain-specific contextualizations of platform concepts (De Reuver et al., 2018).

2 Theoretical background

Digital platforms, openness, and innovation are all well-studied topics in scientific research and closely relate to each other. Furthermore, they are often intertwined with each other and the context they are embedded (De Reuver et al., 2018). To develop a structured overview of healthcare challenges that may be solved by openness, we need to be clear on interpreting some of the key concepts.

2.1 Platform openness

Fundamental to our definition of digital platforms is that platforms host core functionality shared by modules that interoperate with the platform through interfaces. Inherent in this definition is that platforms' functionality can be extended with new services and products coupled to the platform. Related to this definition, many researchers in the fields of information and innovation management have considered digital platforms as modular structures, consisting of a stable core and a variable periphery (e.g., Baldwin and Woodward, 2009). In a more general sense,

platforms can be considered a socio-technical aggregation of technical components (soft- and hardware) combined with organizational arrangements (Tilson, Sorensen and Lyytinen, 2012). It is essential to consider this latter definition because it denotes that technological and organizational arrangements govern platforms openness, and their add-on modules. With this definition, we do not neglect the concept of modularity, but we focus on the interoperability between technology from one or more suppliers.

Platform openness concerns the extent to which external parties can use, develop services, or commercialize a platform (Benlian et al., 2015; Boudreau and Hagiu, 2009). Openness exists in different ways and to different degrees. How a platform is open has significant consequences for the functionality and development of the platform. First, it is important to understand that platform openness is no binary choice but a continuum (West, 2003). Platforms exert different degrees of openness in opening other parts of their platform (Boudreau, 2010) or to which parties (Eisenmann et al., 2009; Ondrus et al., 2015). To understand how platforms in the domain of primary healthcare can be opened, we must be clear in describing the ways platforms can be open or closed. To do so, we use a conceptualization based on Ondrus et al. (2015). They identify different levels of openness, based on Eisenmann et al. (2009), who argue that openness definitions should distinguish the roles in a platform ecosystem. By adding a technology level, a clear separation between actors and technology is made (Ondrus et al., 2015). This results in four levels of openness in a platform ecosystem: (1) sponsor level openness, (2) provider level openness, (3) technology level openness, (4a) demand-side user-level openness, and (4b) supply-side user-level openness. In our conceptualization, we expand on the definition of technology-level openness and refer to it with the concept of platform-to-platform openness.

2.1.1 Level 1: sponsor openness

Platform sponsors exercise property rights over a platform (Eisenmann et al., 2009). Thereby, they can be considered the 'owner' of a platform that can make strategic choices related to technology and governance. With openness on the sponsor level, Eisenmann et al. (2009) refer to the ownership structure. They implicate that a platform is open on the sponsor level when property rights are shared among different actors. Vice versa, a platform is closed on the sponsor level when a single

actor holds property rights. In the absence of a specific definition, we define sponsor level openness as follows: the extent to which multiple actors share the property rights of a platform. This definition incorporates the idea from West (2003), who states that openness is not a binary variable but can be viewed on a continuous scale.

2.1.2 Level 2: provider openness

A platform provider serves as the primary point of contact for the end-users and can be seen as the actor operating the platform (Eisenmann et al., 2009). In a similar fashion as with the sponsor level, Eisenmann et al. (2009) see a platform as open on the provider level when multiple actors provide it. Ondrus et al. (2015) takes a slightly different approach. They see a situation where other actors use the same platform technology as a platform open on the provider level. In this view, an array of horizontally collaborating firms with specific roles and responsibilities could collaborate to provide an inter-industry platform. For this research, we adopt the latter approach. The following definition for provider openness is used: the extent to which multiple actors can use a platform's technology.

2.1.3 Level 3: platform-to-platform openness

Openness on the technology level defines how interoperable a platform is with other platforms and related technologies – through the use of gateways or APIs (Ondrus et al., 2015). However, we see the interoperability of two platforms not only as a technical matter. In addition to technological interoperability, like standardization of interfaces, organizational arrangements must be made for two platforms to be interoperable. Hence, we refer to the interoperability between platforms with the concept of platform-to-platform openness. This view acknowledges that a platform is a socio-technical construct (Tilson, Sorensen, and Lyytinen, 2012). For this research, we use the following definition: the extent to which a platform is interoperable with other platforms (Mosterd, Sobota, van de Kaa, Ding and de Reuver, 2021). An important characteristic of platform level openness is that they both keep on existing if two platforms open up towards each other. Hence, integration is not seen as a form of platform-to-platform openness. Furthermore, this definition incorporates the idea that one should talk about the degree of openness (West, 2003) in two distinct ways: (1) a platform can be partly interoperable with another platform (e.g., only data, but no services can be shared between the

platforms), and (2) a platform can be closed to one platform but open to another. Alternatively, instead of becoming interoperable via a direct gateway, two platforms can also become interoperable via a meta-platform.

2.1.4 Level 4: user openness

The final level of openness relates to the users of a platform. Ondrus et al. (2015, p. 263) state that openness on the user level is concerned with "making the platform accessible in indiscriminate ways to new users." Within user openness, a distinction can be made between demand- and supply-side user openness. In line with Ondrus et al. (2015), we define user openness as the extent to which users from other platforms and/or users not yet part of a platform can join the platform.

2.2 Platform openness and innovation

Platformization -i.e., "a shift from individual products/services to platforms as intermediaries for transactions and for organizing value-creation processes" (Nambisan, Siegel and Kennedy, 2018)- of the digital primary healthcare landscape will change how value is created and how innovation takes place within the domain. Traditionally, innovation took place within the boundaries of organizations or their linear supply chain. With platforms, innovations come from different actors that build their business (partly) around the platform, creating value for end-users (Gawer, 2014). Due to platforms' possibility to leverage a range of value-creating entities, platforms have become powerful stimulants of innovation in many industries (Gawer, 2009; Boudreau, 2010; Cennamo and Santaló, 2019) (a trend that has not yet taken off for healthcare (Hermes et al., 2020)). An example of platforms' innovation capacity is Apple's iOS or Google's Android, which allow Apple and Google to outsource large parts of their R&D by accessing and harnessing a possibly unlimited external pool of resources and capabilities. Moreover, digital platforms allow for generativity, meaning that the functionality of innovations can go beyond the original scope of the platform (Zittrain, 2008; Wareham et al., 2014). Allowing others to contribute to the service or product offerings may thus benefit the platforms' innovation capacity. For platforms to capitalize on this external pool of contributors requires platforms to be open, allowing others access to or control parts of the platform. Besides the given benefits of open collaboration in platforms, openness also poses threats to the platform. Openness can harm the platform's

revenues when a complementor competes with the platform (or its offerings) itself (Eisenmann, 2009). Platform openness can also lower switching costs as products or services become available across different platforms, thereby harming the platform's possibility of locking in users (West, 2003). Another threat is when low-quality external offerings harm a platform's integrity (Wessel et al., 2017). More recently, Karhu et al. (2018) have articulated the threat of forking, a hostile strategy when a third-party exploits an open platform by copying, reverse engineering, or harming the platform. Case in point, platform owners, need to balance openness, granting autonomy to contributors versus restraining contributors' access and power.

3 Method

To attain an in-depth understanding, we took an iterative approach, going back and forth between data collection and analysis, see Figure 1. Although we did not follow the method fully, our iterative approach was inspired by grounded theory principles (Corbin and Strauss, 1990). Two data sources were used:

Desk research - Initial understanding of the domain and its historical development was attained through grey literature (e.g. Idenburg and Dekkers (2018), Idenburg and Phillipens (2018), Kuijpers and Bakas (2017), Bus et al. (2019) and Van Gelder and Zebregs (2015)) and websites (e.g. https://www.nictiz.nl/and https://www.vzvz.nl/).

Discussions with field experts - Kuechler and Vaishnavi (2012) incorporate 'tacit theory' as input to information systems design efforts. This refers to "insights or evidence/experience-based justification for pursuing a novel design" (Kuechler and Vaishnavi, 2012, p. 404). Experts' insights are an useful source for understanding the problem. These insights were gathered through conversations with experts who all worked at companies that develop information systems for first-line care providers.

Analysis approach

Desk research information was presented during a presentation. These concepts were shown to domain experts, who all are experienced in different levels of openness. After each discussion with a domain experts, the information from the slides was iterated until domain experts had no suggestions for further adjustments.



Figure 1: Overview of the approach, inspired by grounded theory

9 expert interviews were held, with software suppliers (6), with consultants (2), with network provider (1), in different roles like Managers Business Development, Product Owners (2), Head of Products, Architect, Directors (2) and Consultants (2).

4 Analysis

What are the consequences of openness to platforms in primary healthcare in The Netherlands? What threats and opportunities arise in these different levels of openness? This section explores and discusses expectations on the impact of platform openness in primary healthcare for the different levels of openness. Figure 2 shows an overview of possibilities for platform openness at different levels in Dutch primary healthcare. The figure visualizes data flows between different levels, for instance platform and 3rd party developers.

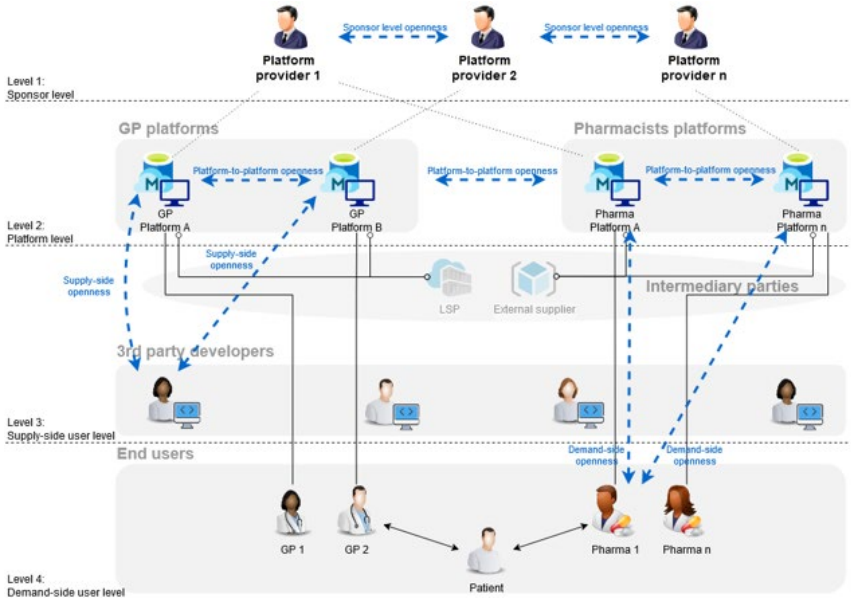


Figure 2: Possibilities for platform openness at different levels in Dutch primary healthcare

4.1 Openness on the sponsor-level

We discussed earlier that multiple sponsors compete for the same user group, for example with nine parties providing their own platform for general practitioners. While openness between these competitors is unlikely, openness is more likely to arise between sponsors that target different types of users, for instance co-opetition or collaboration (see Ondrus et al., 2015) between sponsors of general practitioners and physiotherapists.

Opportunities

Co-opetition between different sponsors can be an interesting strategy for sponsors when they can together reach a set of users that is larger than they each of the platform could on its own (Ondrus et al., 2015). Thus, for the sponsors, this strategy provides the opportunity to expand its user base. Such co-opetition could also present opportunities for users on the demand-side. Combining data gathered on the side of the physiotherapists enables caregivers to be better informed, having the combined database information at their disposal. Furthermore, it could lead to more holistic patient care in which a patient well-being is approached from a combination

of disciplines (phycological, physical and social) (Zamanzadeh et al., 2015). This could also attract new customers to the platform.

Challenges

Ondrus et al. (2015) state the potential of a larger user group as a prerequisite to successful co-opetition between platform sponsors. However, in primary care, there are additional challenges with regard to privacy-preservation and data infrastructure. To what degree are sponsors allowed to combine data from the affiliated platforms? And on the data-level, is it possible to combine the data that is collected in the platforms?

4.2 Openness on the platform-to-platform level

The platform-level can be considered closely related to the sponsor-level, albeit more focused on the interoperability of the actual platforms rather than a strategic collaboration between sponsors.

Opportunities

This openness is expected to yield opportunities. First, it will enhance the opportunity to transfer patient information across different platform providers. This enhanced interoperability will hugely impact a unified experience both for the patient and for the caregiver. It will allow caregivers to see data of a patient also when it is stored in a different platform. Thus, also increasing the amount of information upon which a caregiver can diagnose and treat a patient. Second, to compete on the platform's quality rather than on the quality lock-in mechanisms and the established installed user-base. In the current situation, a platform with a large user base has the advantage that these users have access to the same pool of patient data (namely that in the platform's database). When this data becomes transferrable between platforms, this diminishes the advantage of a large pool of users and consequently requires platforms to compete on their platform's quality. A third advantage lies in the opportunity for big data analysis and the application of machine learning to improve understanding of healthcare diagnosis. When data is accessible and readable in a similar manner across platforms, this can open opportunities for analyzing the pool of data. Advancements in machine learning, together with platform openness,

can give caregivers the opportunity of making more data-driven decisions. And it can help them strengthen their focus on the patient rather than on the administrative burden of requesting information from other databases. Fourth, a shared interoperability standard among platforms may reduce the development costs. Open processes for developing standards can be led to more effective feedback, higher quality products and consequently a higher rate of innovation, as was also repeatedly pointed out by domain experts. One of the ways to achieving openness on the platform level is through a meta-platform. Domain experts consider this option preferable, especially if it entails that one meta-platform could host all the necessary functionality within the primary care domain that now exists in all individual platforms. This way, there remains only one platform that hosts the necessary functions, to which the platforms can plug into and can innovate and compete on additional functionalities and the user experience.

Challenges

A challenge for achieving platform-to-platform openness is setting standards for the format for how data is stored and transferred between the servers of the different platform providers. How to achieve these interoperability standards is a challenge that has yet to be solved within the industry. For a single platform to open up in this way, it is unlikely to be successful as the platform itself will only reap the benefits of enhanced openness if parties open up. Previous studies on platform openness discuss how openness can be achieved. Either interoperability standards can be set de jure, that is, adherence is imposed by law. Second, a platform may face increasing pressure from competing platforms or users that demand open standards to avoid user lock-in (Eisenmann, Parker & Van Alstyne, 2009). A common challenge with platform interoperability is the need to coordinate collaboration in defining and updating standards. Change in standards can be slow or low quality because the platforms' ecosystem needs to consider the platforms with the (s)lowest capabilities. This argument was also mentioned repeatedly by domain experts in primary healthcare in The Netherlands as one of the main barriers to achieve interoperability. Also, decision-making processes are typically slow because they require different platforms to arrive at a shared solution. This same argument was also applied to the meta-platform situation, where all platforms need to adhere to the rules and standards of the meta-platform. In the later situation, additionally, there need to be

governance mechanisms in place to align all affiliated platforms with the meta-platform.

4.3 Openness on the supply-side user level

This type of openness allows third-party developers to build complementary offerings that extend the functionality of the platform. These complementary services, or applications, can be developed for users in caregivers and patients.

Opportunities

One effect of this type of openness is that it significantly reduces the barrier to entry for third-party developers to develop complementary services for the primary healthcare domain. Currently, a developer would either have to develop its digital platform (and compete with established platforms for users). They should go to great lengths to add a piece of software to an established platform. Opening up would lead to a significant reduction in the effort and costs to enter the market and reach an established pool of end-users. Second, it enables platform owners to outsource parts of their R&D. Not only can this reduce costs, but it will also give access to a possibly unlimited pool of knowledge and innovations. While the platform can still provide the core functionality, new services may emerge in its ecosystem. These new services may contribute to more proactive healthcare, higher patient engagement, and better-informed care, for instance, by making use of the power of data analytics. These developments can benefit both caregivers and patients.

Challenges

To successfully enable and stimulate supply-side user openness, platforms in this domain must carefully consider both technical and governance factors. One of the technical challenges is that platforms need to consider how they choose to open their architecture. For instance, the platform's architecture's complexity can affect the willingness of third-party developers to contribute to a platform (Cennamo et al., 2018). Perhaps a more prominent discussion is the governance of healthcare platforms. This question of governance involves questions of how to deal with sensitive patient data stored at the side of the platform owners and how to govern the relationship, control, and financial arrangements between the platform provider

and the complementors. One of the crucial questions to answer is how to design boundary resources that mediate the relationship between the platform provider and the complementor (Hein et al., 2019). How platforms choose to design their boundary resources can significantly affect how they can attract and retain complementors and consequently strengthen their platforms to become more attractive to caregivers and patients.

5 Discussion and Conclusions

Far too often, discussions on using platform openness to stimulate innovation in healthcare are overly simplistic and even unrealistic, suggesting that one integrative platform or open APIs are the only possible solutions. This paper examines alternative ways to open up platforms and stimulate innovation. Especially within the primary healthcare domain, with its complexity in roles, regulations, and ICT infrastructure and where it is notoriously difficult to implement changes, we strongly recommend considering platform openness in its entirety and learn to understand what (combination of) approaches to platform openness can help to boost innovation to make primary care more efficient. Our study shows opportunities to enhance innovation-opportunities at different levels of the platform ecosystem. See Table 1 for an overview of challenges and opportunities of different forms of platform openness.

Table: 1: Overview of challenges and opportunities of different forms of platform openness

	Challenges	Opportunities
Sponsor-level openness	Requires integration of data sources, requires privacy-preservation regulation and architecture.	Access to larger set of users, better informed caregivers, open opportunities for holistic care.
Platform-to-platform openness	Requires standardization efforts of multiple platform providers, slows down the innovation of the platforms.	Greater access to information, greater competition between platforms, less lock-in / winner-takes-all, more data for (machine) learning, lower development costs, in case of meta-platform, the necessary functions and patient data is managed centrally for all patients and caregivers.
Supply-side openness	Requires thought on the platform architecture, governance/access rules, requires boundary resources to regulate access to the platform.	Lower barriers to entry for developers, outsource innovation to developers.

Firstly, opening up platforms towards other platforms, either within or outside of the primary care domain, can lead to better-informed caregivers and can make room for a more holistic approach to patient care. Platform-to-platform openness gives sponsors from different care-disciplines access to a larger pool of users that they would have on their own. It is yet unclear what governance methods can manage the relationship between the sponsors and at the same time ensure adherence to policies and regulations in healthcare. Secondly, openness can be achieved through gateways, APIs or a meta-platform. All three options are expected to enhance the rate of innovation and also ensure better access to information by caregivers. Until now, platform sponsors have shown to be unwilling to open up towards other platforms because of risk of losing market share. Another barrier is that agreement on the terms and technological requirements for platform interoperability is notoriously slow in healthcare. Platforms either strategically fail to comply or do not have the technological means or knowledge to do so, making interoperability a difficult strategy to pursue. Thirdly, supply-side user openness (i.e., opening up the platform to users) has a high potential of boosting innovation by third-party developers. Currently this opportunity has not yet been seized for the lack of suitable platform architectures, governance and boundary resources. Those are required to ensure the quality and security of patient information but also the relationship, control, and financial arrangements between the platform provider and the complementors. These findings not only widen the range of opportunities to stimulate innovation, but they also provide excellent suggestions for further research. By bringing together the complicated and extensive primary care domain and research on (open) digital platforms, we have created a solid foundation to discuss openness and innovation in primary care platforms. This analysis will be the starting point of the further research to explore new ways of openness in primary healthcare. More in detail insights are possible by using design science research in this domain.

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Restructured Work and Employees: A Systematic Literature Review on Digital Transformation Skills for Sustainable Employment

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Abstract Digital transformations (DT) require investment in organizational learning climates in which sustainable employment is key. The challenge is to identify and develop essential employee skills needed to meet the organizational demands posed by DT. So far, research has focused on digital or specific professional skills, leaving the question unanswered as to which specific DT skills are essential; thus, our objective was to identify these skills and to develop a comprehensive DT skills framework. A systematic literature review was conducted to identify and synthesize DT skills. Through template analysis a DT skills framework was developed consisting of five crucial skill dimensions: (1) Digital working skills, (2) Entrepreneurial skills, (3) Collaboration Skills, (4) Communication Skills, (5) Lifelong learning skills, and (6) Evidence-based working skills. Our framework shows that essential DT skills are a combination of digital or technical skills and adaptive skills, inviting HR professionals to align their strategic talent management with digital transformation.

Keywords: digital transformation, skills, sustainable employment, framework, systematic literature review.

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1 Introduction

This study aims to advance theoretical development on digital transformation (DT) skills that essential are for sustainable employment. Rapid and continuous advancements of digital technology, such as increased automation, artificial intelligence (AI), big data, cloud computing, robotics and internet of things (IoT), lead to huge transformations for society, economy, and its organizations (Ivaldi et al., 2022; Trenerry et al., 2021). For organizations to successfully transform, it is important to strongly invest in an organizational learning climate, while for employees, investment in the sustainability of their employment is key. One of the greatest challenges is to identify and develop essential skills that contribute to both the collective learning climate and employment sustainability (Ivaldi et al., 2022). Thus, this study aims to advance theoretical development on digital transformation (DT) skills that essential are for sustainable employment.

Because previous scientific literature has focused predominantly on mapping general 21st century skills, digital competences of citizens, or essential skills for specific professions, it remains largely unclear which employee skills are essential in the context of DT. Hence, the contribution of this study lies in identifying these essential skills and developing a comprehensive DT skills framework. As digital technology has accelerated a blurring of boundaries between industries that lead to a more generic and adaptive skillset (World Economic Forum, 2020), we focus on transversal skill sets rather than skills for specific professions in this study. The following research question is central: *Which DT skills are essential for sustainable employment and how can these skills be synthesized into a DT skills framework?*

2 Theoretical background

The current digital transformation is also being referred to as Industry 4.0, a term that relates to it being considered the fourth Industrial Revolution. As with previous industrial revolutions, this Industry 4.0 has the potential to change many aspects of our lives, be it as citizens, consumers or professionals (Ivaldi et al., 2022). Technologies such as AI, big data, robotics and the Internet of Things will generate an unprecedented capacity for processing, archiving and accessing information, which will impact entire systems (Schwab, 2016). As Frey & Osborne (2017) have demonstrated, every industrial revolution has displaced jobs, companies and entire

industries and replaced them with new jobs (which require new, often more complex skillsets) in new organizations in either new, or dramatically changed industries. Moreover, as the Word Economic Forum (2020) points out, this response will depend on organizational learning that includes employees from all levels of the organization to be successful. Thus, Digital Transformation can be defined as: "A fundamental change process, enabled by the innovative use of digital technologies accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity* and redefine its value proposition for its stakeholders. (*An entity could be: an organization, a business network, an industry, or society.)" (Gong & Ribiere, 2021, p. 10).

Following this definition, strategic leverage of key resources, such as employees, and their dynamic and digital skills forms the core of DT. The scope of these skills ranges from specific digital skills to adaptive skills. To cope with the dynamics of DT, some authors even argue that adaptive skills become more valuable for employees than digital skills (Foerster-Pastor & Golowko, 2018). However, comprehensive insight on essential digital and adaptive skills is lacking and therefore we aim to unpack what the literature has to offer in terms of insights into these future skills.

3 Research design

A systematic literature review was conducted to identify and synthesize DT skills in a transparent and reliable way, in accordance with the PRISMA 2020 approach (Page et al., 2021). The PRISMA 27-item checklist was used for reporting this review in a transparent and complete manner. The process of this study is visualized in the PRISMA 2020 flow diagram, which was slightly adapted for the purpose of this study (see Figure 1).

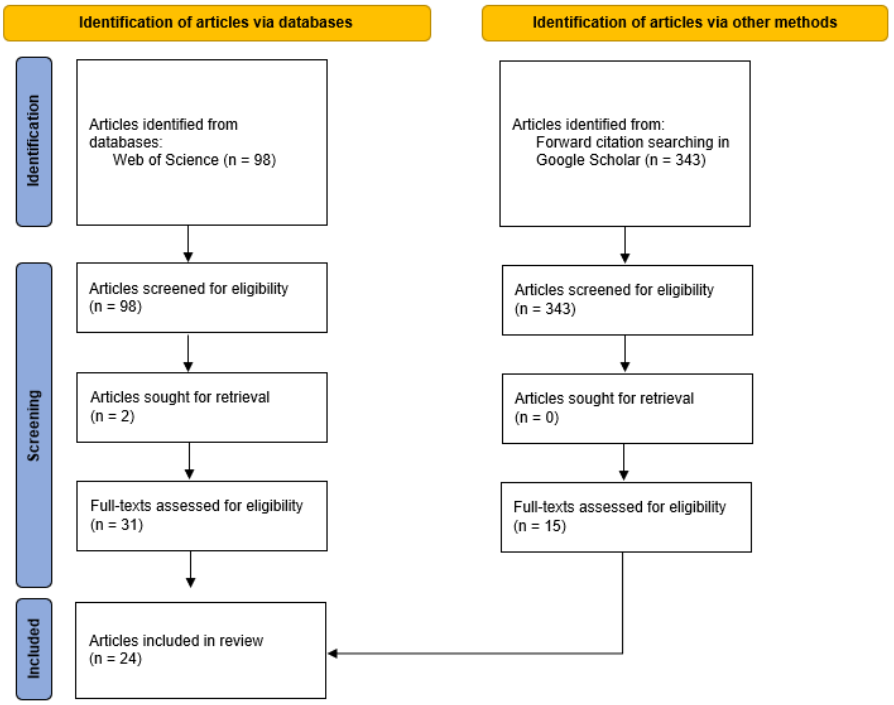


Figure 1: Adapted PRISMA 2020 flow diagram

3.1 Search strategy and selection process

The search strategy consisted of two steps: an advanced search action in Web of Science, followed by a forward citation search in Google Scholar for a selection of articles found in Web of Science.

3.1.1 Step one: selection of articles via Web of Science

For the search action in Web of Science, multiple search terms were combined into one Boolean search operator (see Figure 2). This resulted in an identification of 98 articles. After identification, articles were screened in two stages. In stage one, titles and abstracts of all 98 articles were screened for the following eligibility criteria:

1. includes conceptualizations, definitions and/or measurements of digital transformation skills or a related term, because the goal of this study is to create a digital transformation skills framework based on scientific articles.
2. includes digital transformation skills or related terms that are not too specific for one profession or sector, because the goal is to create a framework that is relevant for a broad array of professions.
3. is published in a peer-reviewed journal, because these journals are regarded as the most reliable source for scientific information.
4. is written in English

Screening was conducted independently by two reviewers and differences in judgements were discussed to reach interrater agreement. This resulted in the exclusion of 67 articles, including two articles that could not be retrieved. For each article, reasons for exclusion were provided. In stage two, the full-texts of the remaining 31 articles were checked, again by two reviewers independently, and differences in judgements were discussed to reach interrater agreement. This resulted in a final inclusion of 21 articles from the Web of Science database.

Abstract of the article contains:				Keywords contain:
('Digital transformation skills' OR 'Digital transformation competences') OR (('Digital skills' OR 'Digital competences') AND 'Transformation') OR (('Skills' OR 'Competences') AND ('Transformation' OR 'Digitalization')) OR ('21st century digital skills' OR '21st century digital competences') OR (('21st century skills' OR '21st century competences') AND ('Digital transformation' OR 'Digitalization'))	AND	('Framework' OR 'Model' OR 'Review' OR 'Measurment' OR 'Instrument')	AND	('Competences' OR 'Skills')

Figure 2: Boolean search operators

3.1.2 Step two: selection of articles via Google Scholar

To be included in the forward citation search in Google Scholar the 21 included papers needed to:

1. include rich definitions of skills or rich descriptions of indicators of skills.
2. have a minimum average of two citations per year. This low minimum was chosen as all articles were published after 2016, and the majority since 2020.

Furthermore, if papers had the same authors, they were only included if they contained different frameworks or models in multiple articles. Based on these criteria six articles from the Web of Science database were selected for inclusion in the forward citation search. In total these six articles were forward cited by 343 papers, which were screened and assessed using the same two-stage process from Step One. This resulted in an inclusion of 3 articles from the Google Scholar database, for a final total of 24 articles included in this study (see Appendix A).

3.2 Analysis and framework development

Template analysis was applied to analyze the concepts used in the articles and to develop a framework of digital transformation skills. Template analysis is a particular style of thematic analysis, in which a coding template is developed based on a subset of data, which is then applied to further data and is revised and refined during this process, leading to a final template (Brooks et al., 2015). The concepts of the most cited article (van Laar et al., 2017) provided the starting point for our coding template. This initial template was applied to the articles, and revised and refined by comparing and adding concepts from the other included articles based on their citation raking from high through low. The final template was visualized as a framework of digital transformation skills, which is presented in the results section.

4 Results

A framework was developed that contains six central skill dimensions, which in turn consist of 6 skill groups and 45 skills (see Table 1). The skill dimensions are described below.

4.1 Digital working skills

Digital working skills refer to all skills needed to accomplish tasks in a digital environment, and consist of two skill groups. The first, basic digital skills, comprises skills such as handling basic software, hardware and social media needed for everyday tasks. The second, advanced digital skills, includes more specific skills such as programming, developing digital content, and cybersecurity.

4.2 Evidence based working skills

The ability to use the best available evidence is the fifth dimension and consists of three skills groups. The first, information processing, is crucial because employees are confronted with large amounts of information and need to able to select and use suitable information. The second, data fluency, relates to the mastery of data-related skills, such as data collection, analysis, interpretation, and data ethics. The third, scientific research skills, consists of skills such as conceptual thinking and the skill to formulate testable research questions that are relevant to the organization.

4.3 Entrepreneurial skills

Entrepreneurial skills are required to adequately respond to and take advantage of DT. Two skill groups are distinguished: 1) being open to novelty, and 2) being able to create value. The first enables employees to create something new, and consists of skills such as creativity and innovativeness, spotting opportunities, and taking initiative. The second enables employees to build solutions that effectively add value for stakeholders, and consists of skills such as critical thinking, problem solving, and valuing ideas.

4.4 Lifelong learning skills

Lifelong learning skills are key to employees' adaptability and consist of two skills: 1) self-directed learning, and 2) experiential learning. The first refers to taking control of one's own professional development and can be viewed as a 'meta-competence'. To prevent skill obsolescence, self-directed learners manage their own progression towards self-defined learning goals by taking actions and reflecting upon these actions. The second entails that employees learn by doing and experimenting during their work and learn what works and what does not, which is needed to successfully engage in more agile project work.

4.5 Communcation skills

Communication skills are needed to transmit information to others via appropriate traditional and innovative (digital) communication channels, ensuring that the meaning is expressed effectively. Essential skills are the ability to chose and use appropriate channels, storytelling, and applying netiquette.

4.6 Collaboration skills

Collaboration skills refer to both online and offline collaboration skills required in the context of DT. Central to this dimension are skills related to collaborating with different types of professionals, e.g. interpersonal and interdisciplinary skills, negotiation skills, and cultural awareness.

Dimension	Sub group	Skill
Digital work skills	Basic digital skills	Handling hardware
		Handling software
		Handling the internet and social media
		Sharing information and data
		Digital ethics
		Solving basic problems
	Advanced digital skills	Programming
		Digital content creation
		Dealing with laws, copyrights and licences
		Cybersecurity & privacy
Evidence based working skills	Data fluency skills	Data collection
		Data management
		Data analysis
		Data interpretation
		Data application
		Data ethics
	Information processing skills	Formulating research questions
		Searching and selecting information
		Information interpretation and evaluation
		Information management

Entrepreneurial skills	Open to novelty skills	Creativity and innovativeness
		Spotting opportunities
		Sensemaking
		Initiative taking
		Self-efficacy
		Resilience
	Value creation skills	Strategic planning
		Critical thinking
		Problem solving
		Anticipation
		Risk taking
		Transformational leadership
Lifelong learning skills		Self-directed learning
		Experiential learning
		Training others
Communication skills		Using appropriate ways to communicate
		Storytelling
		Netiquette
		Digital identity management
Collaboration skills		Negotiation
		Interpersonal skills
		Multidisciplinary skills
		Social intelligence
		Cultural awareness
		Networking

5 Conclusion and discussion

The framework shows that DT skills consist of a combination of digital working skills and adaptive skills, such as entrepreneurial skills. As Table 1 shows, these dimensions consist of several interrelated skills that are relevant for a broad array of professions. These skills increase employability, and as such, sustainable employment.

The framework is an important scientific step in defining and synthesizing essential skills in the context of DT. The primary contributions of this framework are twofold. First, the framework adopts a broad perspective on skills that are relevant for multiple professions and sectors, thus allowing for the identification and emphasis of skills that transcend industries. Second, the framework focuses on a combination of digital working skills and adaptive skills.

5.1 Limitations and future research

The focus on essential DT skills for a broad array of professions and sectors has the consequence that profession specific skills are not included in the framework of this study. Therefore, a suggestion for future research is to build upon this framework by creating different extended versions of it by adding essential skill dimensions for specific professions and sectors. For example, by adding a digital pedagogical skill dimension for teachers or a digital health skill dimension for healthcare professionals.

Furthermore, by defining skill dimensions, skill groups, and specific skills, this study contributed to providing conceptual clarity on DT skills. This is an important precondition for future research aimed at developing scientific instruments to measure or assess DT skills and studying DT skills at the workplace. Therefore, the next step in future research is to operationalize the skills of this DT framework and to develop validated and reliable scientific instruments..

5.2 Practical implications

This study calls upon HR professionals to adapt their strategic talent management to the digital era and to take responsibility for sustainable employment through professional development. This can involve up-skilling, which entails developing relevant skills to add to one's skillset when job requirements change, or re-skilling, which entails developing new skill sets when certain jobs become obsolete and new jobs with different requirements emerge (Santos et al., 2021).

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RESEARCH IN PROGRESS

EXPLORING SOCIAL MEDIA USAGE AMONG TURKISH REFUGEES AND ASYLUM SEEKERS IN NORWAY

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Abstract Social media plays an important role in the lives of refugees. In this study, we explored social media usage among Turkish refugees and asylum seekers settled in Norway. The relationship between social media usage and demographic variables has been examined. An online survey was used for data collection. The most commonly used social media platforms among participants are WhatsApp, YouTube, and Facebook. Among demographic variables, only age was found to have a significant relationship with social media use among participants. A significant negative correlation was detected between age and social media use.

Keywords: social media usage, Turkish refugees, Norway.

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1 Introduction

According to the 1951 Refugee Convention, "a refugee is someone who is unable or unwilling to return to their country of origin owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group, or political opinion." (the United Nations High Commissioner for Refugees (UNHCR)). The refugee crisis has been one of the global issues in the last decades, and the number of refugees in the world has been increasing.

In this article, we focus on the social media use of Turkish refugees and asylum seekers settled in Norway. Following the failed coup attempt in July 2016, large-scale political purges have been carried out by the Turkish government that have affected all areas of society in Turkey (NOAS, 2021). Journalists, lawyers, judges, teachers, academicians, police and military personnel have lost their jobs, and the purges have driven many Turks to flee to Europe (NOAS, 2021). According to the Norwegian Directorate of Immigration (UDI), Turkish citizens were the largest group of asylum seekers in Norway in 2018, with 765 people seeking asylum (UDI, n.d.).

Considering the high education and previous political engagement of most of the Turkish refugees in Norway, it is reasonable to believe that this population group is familiar with and active in social media use. In contrast, previous research shows that immigrants in Norway generally have lower (education and) digital skills than the average population of Norway, even though many use social media (Guthu & Holm, 2010). New, more updated research is needed, which consider changes in the demography of immigrants and refugees in Norway. Therefore, we argue that it is especially relevant to obtain more knowledge about the social media use of Turkish refugees and asylum seekers.

As part of an ongoing research, this study explores social media usage among Turkish refugees in Norway and its relationship with demographic variables. Our research question is: Which demographics relate to social media use among Turkish refugees and asylum seekers in Norway?

1.1 Social Media and Refugees

Information and communication technologies (ICTs), especially the internet, have been an integral part of modern society. These technologies have radically affected societies and also transformed the experience of international migration (Charmarkeh, 2013). Smartphones, the internet and social media platforms are crucial for refugees. These technologies help refugees access information and communication through the whole migration process. With having communication and social features, social media platforms are critically important for refugees.

Social media has the potential to help refugees develop new social networks in a new country as well as maintain social networks in their homeland. Dekker and Engbersen (2014) identified four relevant ways in which social media facilitates international migration, such as enhancing the possibilities of maintaining strong ties with family and friends, addressing weak ties that are relevant to organizing the process of migration and integration, establishing a new infrastructure consisting of latent ties, and offering a rich source of insider knowledge on migration that is discrete and unofficial.

Refugees use social media platforms not only to communicate with the social networks but also to access critical information such as asylum and possible destinations for migration, employment opportunities, living conditions and housing (Ahmad, 2020). Social media platforms and smartphones are used primarily by refugees for communication, translation, information, navigation, and representation (Kaplan, 2018). Smartphones offer important tools and applications for refugees, such as translator, map, compass, GPS, and social media apps. Refugees often access social media and other online information via smartphones (Dekker, Engbersen, Klaver, & Vonk, 2018).

Despite its benefits, social media is also one of the major sources of misinformation today. Social media can provide refugees with rumours, unrealistic or even false information (Dekker & Engbersen, 2014; Dekker et al., 2018). These rumours or misleading information can be about the asylum process, the length of the process to obtain a residence permit and the process for family reunification (Dekker et al., 2018).

Although internet use is quite high across Norway, ICT and social media use among refugees are not well covered in the academic literature of the Norwegian context (Whiting & Williams, 2013). Even though social media provide a relatively cheap, media-rich, and easily accessible means of communication, their use by refugees is not without challenges (Dekker et al., 2018). Therefore, this study will contribute to the literature by exploring social media use among refugees.

2 Methodology

In this study, we used an online survey which was developed and administered by using SurveyXact. The survey link was distributed by WhatsApp and e-mail. The snowball sampling method was used to recruit respondents. Participants were requested to send the survey link to other Turkish refugees living in Norway. Participation in the survey was anonymous and voluntary. The invitation to participate in the online questionnaire was sent in December 2021 via WhatsApp and e-mail with a link to the survey.

2.1 Survey Instrument

The survey consisted of questions related to the demographics of respondents (gender, age, marital status, education level, etc.), social media usage, acculturative stress, mental well-being and life satisfaction, and included several questions about social media usage. Survey participants were asked to indicate the social media platforms they use and the average daily social media usage time. To measure social media use intensity, we used the Social Media Use Intensity Scale (SMUIS) (Cain & Imre, 2021), which was adapted originally from Social Media Use Integration Scale (Jenkins-Guarnieri, Wright, & Johnson, 2013). A five-point Likert scale was used to measure. The response items ranged from 1= strongly disagree to 5= strongly agree. The survey was translated into Turkish and tested with ten Turkish refugees living in Norway before distribution.

3 Findings

3.1 Participants

The first 100 completed responses were used for analysis in this study. Eight (8) responses were not taken into account as they could not be identified as refugees. Therefore, the participants in the study consisted of 92 Turkish refugees in Norway. Table 1 shows the demographic characteristics of the respondents.

Table 1: Demographic characteristics of the respondents

Variables	Category	Frequency	Percentage
Gender			
	Female	28	30.4
	Male	64	69.6
Age			
	18-25	7	7.61
	26-30	14	15.22
	31-35	19	20.65
	36-40	16	17.39
	41-45	19	20.65
	46-50	14	15.22
	50+	3	3.26
Marital status			
	Married	81	88.0
	Single (Never married)	9	9.8
	Divorced	2	2.2
Level of education			
	Less than high school degree	2	2.2
	High school degree or equivalent	11	12.0
	Vocational school of higher education (2 years)	5	5.4
	Bachelor's degree (4 years or more)	52	56.5
	Master's degree	21	22.8
	Doctoral degree	1	1.1
Employment status*			
	Introduction programme	54	58.70
	Unemployed	13	14.13
	Studying (high school, university, etc.)	18	19.57
	Employed (full-time, part-time or self-employed)	35	38.04
Length of time lived in Norway			
	Less than 6 months	3	3.3
	6 months to less than 1 year	2	2.2
	1 year to less than 2 years	8	8.7
	2 years to less than 3 years	24	26.1
	3 years to less than 4 years	51	55.4
	4 years to less than 5 years	4	4.3

* Respondents could choose more than one option

69.6 percent of the participants were male, and the remaining were female. The age of the participants ranged from 19 to 60 years old (Mean= 37.4, SD= 8.3). 60.6 percent of the participants were between 19 and 40 years old, and the remaining were 41-60 years old. Eighty-eight (88) percent of the participants were married, 9.8 percent were single, and 2.2 percent were divorced.

The majority of the participants (85.8%) had higher education, with 56.5 percent having a bachelor's degree, 22.8 percent had a master's degree and one participant had a doctoral degree. The participants had been living in Norway between less than 6 months and 5 years at the time of the data collection.

In the questionnaire, participants were asked to indicate which social media platforms they used. Among participants, the most commonly used platform was WhatsApp (100.0 percent), followed by YouTube (83.70 percent), and Facebook (80.43 percent). WhatsApp is one of the most popular social media platforms among refugees (Briggs, 2021). Table 2 shows the social media platforms used by the respondents.

Table 2: Social media platforms used by respondents

	Frequency	Percentage
WhatsApp	92	100.00
YouTube	77	83.70
Facebook	74	80.43
Instagram	57	61.96
Twitter	52	56.52
LinkedIn	19	20.65
Snapchat	8	8.70
Pinterest	8	8.70
TikTok	4	4.35
Other	2	2.17

Table 3 shows the respondents' average daily social media usage time. The majority of the respondents indicated that they use social media less than two hours a day. Forty (40) percent of the respondents' average social media use time was one to two hours per day.

Table 3: Social media platforms used by respondents

	Frequency	Percentage
Less than 30 min.	5	5.4
30 min to less than 1 h	16	17.4
1 h to less than 2 h	37	40.2
2 h to less than 3 h	24	26.1
3 h to less than 4 h	8	8.7
4 h to less than 5 h	1	1.1
More than 5 h	1	1.1

3.2 Data Analysis

An exploratory factor analysis with Varimax rotation was performed on SMUIS items using IBM SPSS (version 25). The result for KMO was 0.723 that is above the acceptance level. The Bartlett's test of sphericity results were as follows: Chi-Squared= 247.370, df = 45, and p <0.0001. Table 4 shows the results of the factor analysis. For the data of this study, the Cronbach's alpha coefficient for overall scale scores was 0.767, and for scores on subscale 1, Social Integration and Emotional Connection (SIEC), and subscale 2, Integration into Social Routines (ISR), were 0.802 and 0.546, respectively.

Table 4: Rotated factor matrix for social media use intensity scale

Statements	Factor 1	Factor 2
1. I feel disconnected from friends when I have not logged into my social media sites.	.558	
2. I would like it if everyone used social media sites to communicate.	.794	
3. I would be disappointed if I could not use social media sites at all.	.724	
4. I get upset when I cannot log on to my social media sites.	.701	
5. I prefer to communicate with others mainly through social media sites.	.684	
6. Social media sites play an important role in my social relationships.	.689	
7. I enjoy checking my social media site accounts.		.674
8. I do not like to use social media sites. a		.700
9. Using social media sites is part of my everyday routine.		.696
10. I respond to content that others share using social media sites.		.452

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Reverse coded.

3.3 Variables

3.3.1 Dependent Variable

An overall average total score for the Social Media Use Intensity Scale (SMUIS) was used as the dependent variable. SMUIS constitutes two subscales. The first 6-item subscale is entitled Social Integration and Emotional Connection (SIEC), and the second 4-item subscale is called Integration into Social Routines (ISR) (Cain & Imre, 2021; Jenkins-Guarnieri et al., 2013). The overall score for the SMUIS was calculated as an average of the two subscale scores. Table 5 shows Social Media Use Intensity Scale items.

3.3.2 Independent Variables

Demographics of respondents of the study were used as independent variables within the regression model. Table 1 contains the demographics of respondents, such as gender, age, marital status, education level, employment status, length of time living in Norway.

Table 5: Social media use intensity scale items

Statements	M	SD
1. I feel disconnected from friends when I have not logged into my social media sites. a	2.83	1.09
2. I would like it if everyone used social media sites to communicate. a	3.13	1.09
3. I would be disappointed if I could not use social media sites at all. a	2.77	1.08
4. I get upset when I cannot log on to my social media sites. a	3.12	1.09
5. I prefer to communicate with others mainly through social media sites. a	2.89	1.05
6. Social media sites play an important role in my social relationships. a	2.96	1.07
7. I enjoy checking my social media site accounts. b	3.71	0.79
8. I do not like to use social media sites. b, c	3.57	0.99
9. Using social media sites is part of my everyday routine. b	3.52	0.82
10. I respond to content that others share using social media sites. b	3.02	1.01

M = mean; SD = standard deviation; Scale range for items: 1=strongly disagree to 5= strongly agree, a Part of Social Integration and Emotional Connection subscale, b Part of Integration into Social Routines subscale, c Reverse coded.

A general linear model was used to assess the association between social media use (SMUIS, dependent variable) and the demographic variables of the respondents. The general linear model analysis revealed that there was a significant effect of age. Results indicate that there are no significant findings for other demographic variables. Table 6 presents the results of the general linear model.

Table 6: Results of the general linear model

Variables	Mean Square	F	Sig.
Age	1.297	4.106	.046
Gender	.161	.511	.477
Marital status	.187	.593	.555
Education level	.169	.535	.710
Length of time lived in Norway	.137	.433	.824

R Squared = .101 (Adjusted R Squared = -.049)

The results of the correlation analysis show that there is significant negative correlation with age and social media use (SMUIS ($p<0.05$), average daily social media usage ($p<0.01$)). Table 7 shows the results of the correlation analysis.

Table 7: Results of correlation analysis

	(1)	(2)	(3)	(4)	(5)	(6)
Age (1)	1.00					
Gender (2)	.159	1.00				
Education level (3)	.007	.111	1.00			
Length of time lived in Norway (4)	.183	.096	.010	1.00		
SMUIS (5)	-.211*	-.150	-.090	.030	1.00	
Average daily social media usage (6)	-.289**	.023	-.029	-.114	.049	1.00

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

4 Conclusion

In this current study, we explored social media usage among Turkish refugees and asylum seekers in Norway as a part of a larger study. We examined the relationship between social media usage and the demographic variables of the participants. In addition to questions about social media usage among participants, the Social Media Use Intensity Scale was used in the study.

It was found that WhatsApp, YouTube, and Facebook were the most commonly used social media platforms among participants. All of the participants reported using WhatsApp. The duration of social media usage in a day varies. Most respondents indicated that they used social media less than two hours a day. Among demographic variables, only age was found to have a significant relationship with social media use among participants. The results indicated that there was a significant negative correlation between age and social media use.

The limitations of this current study should be acknowledged in interpreting the results. We used the snowball sampling method to recruit respondents. The sample size was limited. The study sample may not be fully representative of the refugee population in Norway. An online survey was used for data collection. Other significant variables such as income have not been collected. Interviews can give a deeper understanding of social media usage among refugees. Future studies can also examine other demographic variables affecting social media usage.

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RESEARCH IN PROGRESS

COMPARISON OF BPM MATURITY AND PERFORMANCE OF THE DUTCH DEPARTMENT OF DEFENCE WITH OTHER SECTORS

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Abstract This study investigates the Business Process Management (BPM) maturity and process performance of the Dutch Department of Defence (DDoD). Like any other organisation, defence departments use BPM to manage their daily business processes. Despite using BPM, the organisation has never undertaken the initiative to analyse its BPM Maturity level and process performance. This paper presents the first results of such a study and compares this to similar military organisations, non-profit organisations and other organisations in the private sector. The DDoD BPM Maturity index score of 2.66 is similar to that of peer organisations. The study provides some suggestions for research and practical implications for further Business Process Maturity development of the DDoD organisation.

Keywords: business process management, BPM maturity, department of defence, process performance.

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1 Introduction

The Dutch Department of Defence (DDoD) is an organisation that has used Business Process Management (BPM) for decades to manage business processes. Nevertheless, differences are seen in how various parts of the organisation implement BPM in practice. The DDoD has regular audits by the Netherlands Court of Audit (Auditdienst Rijk, 2020) and the Dutch Safety Board in case of severe safety breaches or incidents (OVV, 2017). Some of the reports of those audit agencies state that the DDoD has well-written and documented processes, rules and (safety) procedures. Nonetheless, there has been a breach of those because they were not followed thoroughly or monitored (Moen & Norman, 2009); the inquiries could not clarify why, when and how procedures or processes were ignored.

Based on the above, this paper's objective is to study the actual level of BPM Maturity and Performance of the DDoD. Therefore, the research question we pose is: **'how do the BPM Maturity and process performance of the Dutch Department of Defence compare to similar organisations and those from other sectors?'** . The remainder of this paper is structured as follows: in the next chapter, we discuss the literature on the concept of Business Process Management (BPM) in the context of our study, followed by the research method in chapter 3. Chapter 4 continues with the results, and the paper concludes with Conclusions, implications, limitations and further research in Chapter 5.

2 Theoretical Background

We adopted the integrated BPM model from Ravesteyn et al. (2012) for this research. This model has been validated and used for analysing the BPM Maturity of various Dutch organisations (Ongena & Ravesteyn, 2020). The data collected by the application of this model provides us with the unique opportunity to compare with a broad range of organisations that were analysed for multiple years (Exalto-Sijbrands, Maris, & Ravesteyn, 2016; Janssen, Nendels, Smit, & Ravesteyn, 2015; Ravesteyn et al., 2012). The questionnaire of this BPM model covers topics such as the level of awareness there is regarding BPM within the organisation; how processes are measured and managed; what level of knowledge and resources is available to initiate BPM projects; the use of technology in BPM projects; the overall maturity of BPM; and the performance of the organisational processes.

2.1 Business process management maturity

Prior research shows that BPM Maturity Models help to improve process performance (Davenport & Short, 1990; de Bruin, Rosemann, Freeze, & Kulkarni, 2005; Fisher, 2004). The BPM community agrees that any activity to achieve BPM Maturity improvement benefits process performance (Ravesteyn & et al., 2012). However, opinions differ on the capabilities that need to be developed to improve process performance and achieve a higher BPM Maturity and which contextual factors are involved (Ravesteyn & Batenburg, 2010; Schmiedel, Recker, & vom Brocke, 2020). Furthermore, there is disagreement on how process performance should be measured (Ravesteyn et al., 2012) and on the optimal BPM, Maturity model to measure the maturity of managing business processes (Niehaves, Plattfaut, & Becker, 2013; Niehaves et al., 2013).

2.2 BPM within the public sector

Santana et al. (2011) see a difference between public and private organisations in the adoption, application and motivation of the implementation of BPM. One possible explanation is that public organisations are not profit-oriented. Furthermore, these organisations have to deal with an outdated IT landscape and a rigid bureaucracy (Syed et al., 2018). In contrast to public institutions, private organisations strive for cost efficiency. Value creation and meeting customer needs are central to them. Most governments rarely benchmark their process performance. Nor are they known as early adopters of new technologies and methodologies such as BPM because (continuous) innovation does not always have their highest priority. Politics and regulations often determine their change agenda. The lack of attention by governments for BPM is confirmed by Syed et al. (2018) and Niehaves et al. (2013), who did not find many studies on BPM initiatives in the public sector.

2.3 BPM within hierarchical organisations

From BPM in the public sector, we move to BPM in hierarchical organisations like defence organisations. De Waal et al. (2017a) analysed the BPM Maturity and process performance of the Peruvian Air Force (PAF). The PAF changed from a functional business-driven organisation to a business process-oriented organisation. In 2014, senior leaders started this transition. Two years after the start, De Waal et

al. determined that the developments and the results were not significant and lagged behind the project goals.

Another project that showed a long project duration due to delay was the implementation of BPM at the German Department of Defence. Together with implementing an Enterprise Resource Planning (ERP), that project took ten years (Stein, 2011). It was partly due to the rigid hierarchical structure of the organisation. A further example of a slow BPM project is the Spanish Navy, where implementation took fourteen years (Escrigas Rodríguez, 2011). These change trajectories in both countries were accompanied by exceptionally long lead times. This was because of the rigid command structure and aversion to change.

2.4 Conceptual model

BPM Maturity Models are used to measure the BPM Maturity. The BPM Maturity Model chosen for this study measures maturity based on seven dimensions (Process awareness, Process description, Process measurement, Process management, Process improvement, Process resources and knowledge, and IT applications). The dimensions of the BPM Maturity construct are based on the Capability Maturity Model Integrated (CMM Development Team, 2010) and elements from various studies (de Bruin, Rosemann, Freeze, & Kulkarni, 2005; Rosemann, de Bruin, & Hueffner, 2004).

The meaning and number of associated questions per dimension are explained in Table 1.

The other main component, process performance, is shown in Table 2 and consists of 12 variables (Cost, Traceability, Efficiency, Lead Time, Customer Focus, Continuous Improvement, Quality, Measurability, Employee Satisfaction, Competitive Advantage, Flexibility, Understandability). The process performance dimensions are derived from studies conducted by Hüffner (2004) and van Rudden (2007).

Table 1: Description BPM Maturity dimensions. Source: Ravesteyn et al. (2012)

Dimension	Description	No. of Items
Process awareness	Management realizes the importance of a process oriented organization and includes this in its strategy	4
Process description	Processes and related information within the organization are identified and captured in process descriptions	6
Measurement of processes	A system to measure and control processes is in place in order to be able to improve processes	5
Management of processes	Process owners are assigned within the organization whom are "horizontally" responsible for managing processes	5
Process improvement	The organization strives to continually improve processes and there is a system in place to enable this.	6
Process resources and knowledge	The organization has adequate resources (such as people with process knowledge) to create a "culture of process orientation"	4
Information Technology	The organization uses IT to design, simulate and execute processes, and to provide real-time measurement information (key performance indicators)	7

Table 2: Process performance characteristics. Source Ravesteyn et al. (2012)

Process Performance Characteristic	Statement
Costs	The processes within the organization are executed against acceptable costs
Traceability	Processes within the organization are easily traceable (thus transparent)
Efficiency	Processes within the organization are efficient
Lead-time	The processes within the organization have an acceptable lead-time
Customer focus	Processes within the organization are customer centric
Continuous improvement	The processes within the organization are continuously being improved
Quality	The results delivered by processes within the organization are of good quality
Measurability	Processes within the organization are easily measurable
Employee satisfaction	Processes within the organization contribute to the employee satisfaction
Competitive advantage	The processes within the organization give our organization a competitive advantage
Flexibility	Processes within the organization can easily be changed
Comprehensibility	Processes within the organization can be understood by everybody

Measuring BPM Maturity ánd process performance helps us assess whether improving maturity positively impacts process performance. Maturity is indexed based on the same levels as the CMMI model: 1 – Initial; 2 – Managed; 3 – Defined; 4 – Quantitatively Managed; 5 – Optimising. The meaning of each level is explained in Table 3.

Table 3: CMMI levels. Source: Poulin (2003)

Level	Characteristics
1. Initial	The process is informal and largely improvised, and performance is unpredictable.
2. Managed	A process is defined within the scope of each undertaking (e.g. task, work package, enhancement, project). Focus is placed on stabilizing the approach used to carry out the work associated with each individual undertaking. This approach may substantially differ for each undertaking, even within a given category, and this is acceptable at maturity level 2.
3. Defined	An organizational process is in place and consequently, the emphasis is directed at defining such a process from the best practices implemented in connection with past and current undertakings. The resulting process is then adapted to the needs of each new undertaking. Maturity level 3 also stresses the establishment and use of a repository in connection with future work, in which the data gathered as part of performing the work is consolidated.
4. Quantitatively Managed	The process defined at maturity level 3 is instrumented, quantified and characterized statistically, and the focus is placed on controlling the process outputs with respect to statistical parameters. When enough information has been gathered on the process, its outputs can be monitored in order to determine whether or not they are under control, in the sense that the measurements that characterize them fall within the allocated ranges for the categories of undertakings in the organization.
5. Optimizing	The quantitative data is used to improve the process by tightening the control parameters established at maturity level 4, in order to improve productivity and reduce costs. The causes of random variations observed with collected measurements are investigated in order to determine if they can be removed or reduced, which would result in a more accurate planning, more efficient execution, better products and a more capable process. Continuous improvement becomes a way of life in order to satisfy the business objectives of the organization.

As shown in Figure 1 on the next page, the multidimensional conceptual model comprises two main components: BPM Maturity and Process Performance (process performance).

The research question aims at comparing the situation at DDoD with other organisations. The quantitative part of the study focuses on surveying the BMP Maturity and process performance. The qualitative part (interviews) of our study complemented this approach.

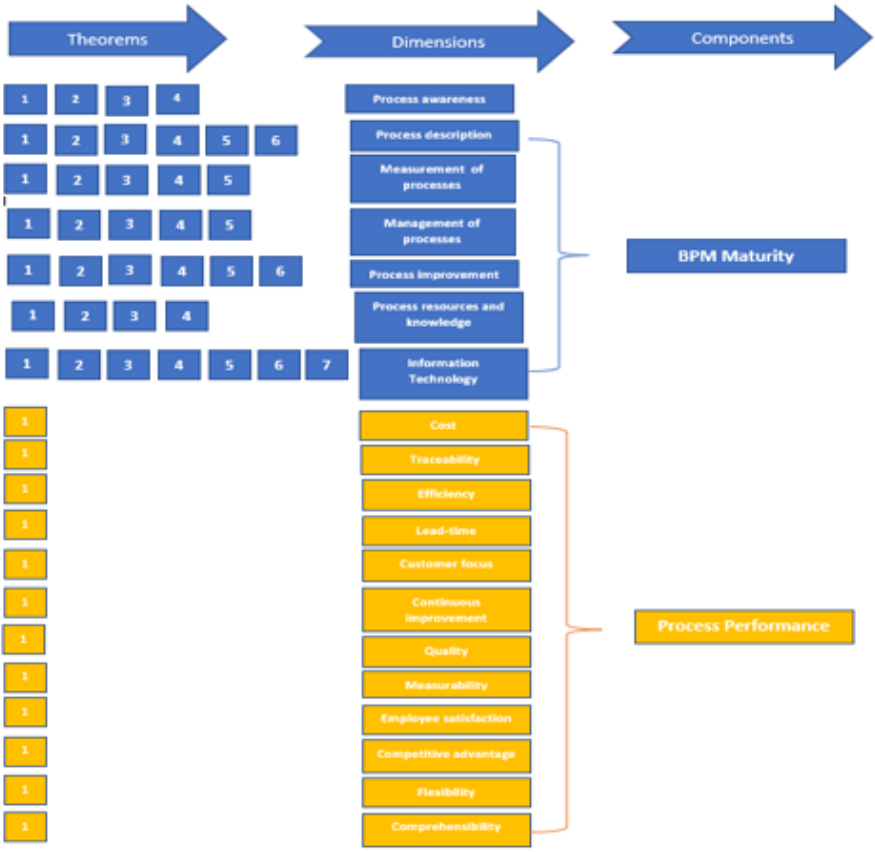


Figure 1: Conceptual Model

3 Research Method

3.1 Data collection

We sent out the survey to selected personnel of the DDoD. Respondents were selected based on their roles in business processes such as IT, Purchasing, Operational Management, and Material Logistics. We used a validated questionnaire used in earlier studies using the same BPM Maturity model (De Waal, Maris, & Ravesteyn, 2017b; Ravesteyn et al., 2012).

The survey contained 49 questions on the main concepts, 37 questions are related to the seven dimensions to measure the level of BPM maturity, and 12 questions addressed the process performance. A Likert scale from 1 to 5 was used for each statement to indicate whether the participants strongly disagreed, strongly agreed, or stayed neutral. In addition, we asked three general questions about how knowledgeable the participants were about BPM. A total of 290 respondents started to fill in the survey, 135 of whom finished, giving a response rate of 16%.

From the Cronbachs alpha values between .803 and .932, all higher than .7 (Twigg, 2010, p.673), we can derive a high internal consistency of the BPM Maturity and process performance dimensions (see Table 4). The overall Cronbach's alpha of the BPM Maturity model is .929 (seven items; $\alpha = .929$).

Table 4: Reliability of BPM Maturity and Process Performance Scales (N = 135)

Construct/ Dimension	Number of items	*N*	Cronbachs alfa	Cronbach's alpha if Items Deleted
BPM Maturity	**7**	135	.929	.937
Process Awareness	4	135	.803	.950
Process Description	6	135	.922	.944
Process Measurement	5	135	.895	.943
Process Control	5	135	.885	.940
Process Improvement	6	135	.897	.943
Process Resources	4	135	.831	.945
Process IT Tools	7	135	.914	.954
Process Performance	**12**	135	.932	.947

To validate the construct validity of the measurement of BPM Maturity, we carried out a Principal Component Analysis (PCA) which resulted in a factor solution with a value of 4.935—accounting for 70.50% of the explained variance. The Cronbach's alpha of .929 confirmed the reliability of the scale. Similarly, a PCA was performed to measure the validated process performance. This resulted in a one-factor solution with an eigenvalue of 6.950, accounting for 57.914% of the explained variance. The reliability of this scale is confirmed with a Cronbachs alpha .932.

To better understand the data collected from the survey, we shared the findings from the survey data with a group of respondents familiar with BPM activities at DDoD. In total, seven people were interviewed. The interviews were summarised and analysed. We also collected secondary data for analysis. The main goal was to gather more information and data on the BPM initiatives, capabilities improvement plans and projects that the DDoD undertakes to improve the BPM Maturity and process performance.

4 Results

Previous studies have shown a relationship between process maturity and the process performance of an organisation (De Waal et al., 2017b; Ravesteyn et al., 2012; Ongena and Ravesteyn, 2019). This relationship was investigated using a single Pearson correlation analysis. The results of this analysis are presented in Table 5. Figure 2 illustrates that the BPM Maturity relates to Process Performance. The correlation coefficient (R) is positive (+1) and amounts to .766. The adjusted coefficient R2 is .587. This means that: there is a positive relationship between BPM Maturity and process performance; BPM Maturity explains 59% of the variance in process performance. There is a strong correlation between BPM Maturity and process performance because the correlation coefficient is greater than 0.5. The regression with process performance as dependent variable and BPM Maturity as explanatory variable is significant: $F(1,133) = 188{,}839$, $p < .001$. The regression coefficient of BPM Maturity is .797 and significant ($t(133) = 13{,}742$; $p < .001$). However, when looking at the multiple regression, the adjusted R2 is .616. The individual BPM Maturity components explain 62% of the process performance. Finally, analysing the separate dimensions shows that Process Resources & Knowledge (.731) and Process Improvement (.723) have strong correlations to Process Performance. Regarding the Process Resources & Knowledge dimension, these findings support earlier studies that found this dimension paramount in improving process performance (De Waal et al., 2017b; Ongena and Ravesteyn, 2019).

Table 5: Correlation between BPM Maturity dimensions and Process performance

	Process Performance	Process Awareness	Process Description	Process Measurement	Process Control	Process Improvement	Process Resources	Process IT Tools	BPM Maturity
Process Performance	1.000	.599**	.661**	.650**	.672**	.723**	.731**	.460**	.766**
Process Awareness	.599**	1.000	.582**	.570**	.631**	.586**	.598**	.469**	.747**
Process Description	.661**	.582**	1.000	.806**	.768**	.735**	.654**	.504**	.866**
Process Measurement	.650**	.570**	.806**	1.000	.830**	.732**	.630**	.581**	.883**
Process Control	.672**	.631**	.768**	.830**	1.000	.797**	.735**	.630**	.923**
Process Improvement	.723**	.586**	.735**	.732**	.797**	1.000	.746**	.527**	.877**
Process Resources	.731**	.598**	.654**	.630**	.735**	.746**	1.000	.535**	.833**
Process IT Tools	.460**	.469**	.504**	.581**	.630**	.527**	.535**	1.000	.725**
BPM Maturity	.766**	.747**	.866**	.883**	.923**	.877**	.833**	.725**	1.000

** Correlation is significant at the 0,01 level (2-tailed).

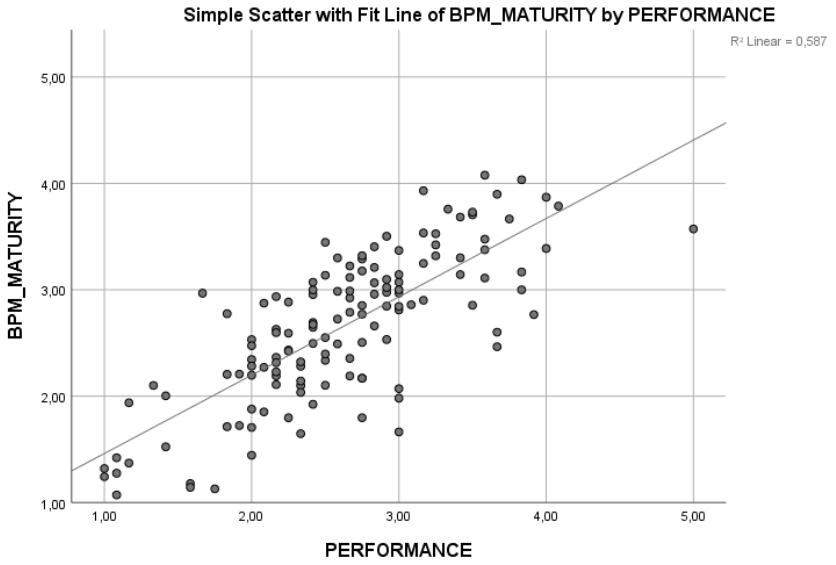


Figure 2: Correlation between BPM Maturity and Process performance in scree plot

4.2 BPM Maturity and Performance of the DDoD

To determine the BPM Maturity and process performance of the DDoD, only fully completed surveys (N = 135) were included.

Based on the survey analysis, the BPM Maturity index of DDoD is 2.66, and the process performance is 2.62 on a scale of 1 to 5. We calculated the average of the components of the BPM Maturity and process performance of the DDoD and compared these with data from other studies (Ongena and Ravesteyn, 2020).

We divided that data into four groups, namely, the private sector (BV NL), the Peruvian Air Force (PAF), (local and federal) governments and Non-profit organisations (GOV & Nonprofit), and the DDoD (DEF NL). These four groups we plotted in a spiderweb diagram (figure 3).

The benchmark shows that the BPM Maturity of the DDoD (DEF), the Peruvian Air Force (PAF) and of other governments (GOV & Non-Profit) are close to each other, i.e., at level 2, Managed. The private sector (BV NL) scores higher with level 3 which means many organisations have reached the Defined level of maturity.

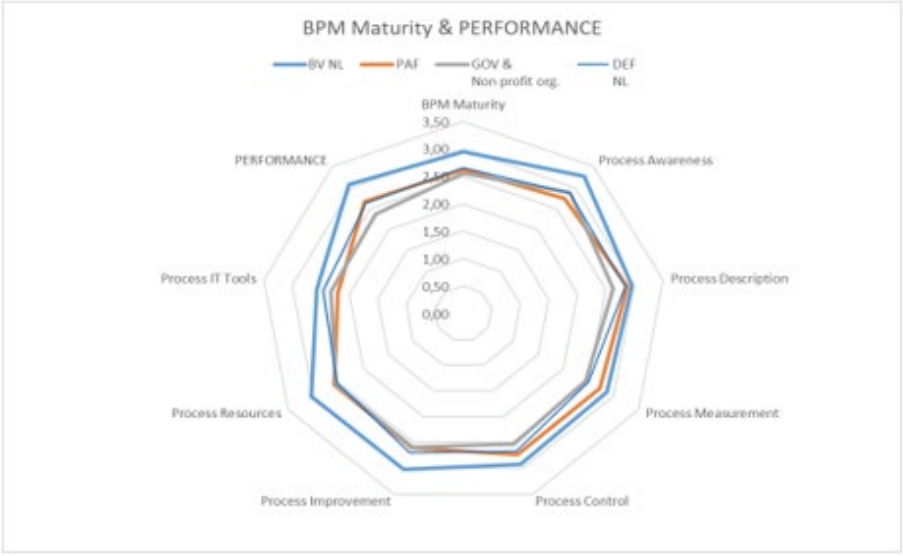


Figure 3: Spiderweb diagram benchmark.

Benchmarking and ranking based on the BPM Maturity of all groups provide the following order: the first place is for the Private sector (BV-NL) with a Maturity of 2.95, the highest maturity of all. This score indicates level 3, Defined;

the second place is DDoD (DEF) with a Maturity of 2.66; the third place goes to the PAF with a Maturity of 2.63; the fourth place is for GOV & Non-Profit with a Maturity of 2.56.

After ranking the BPM Maturity of the groups, we compared and ranked the performance of all the groups. The ranking went as follows: the first place goes to the private companies with the highest score for process performance and an average of 3.08. This score is a level 3 (Defined); the second place goes to the PAF with a process performance of 2.66; the third place is for DDoD with a process performance of 2.62; the fourth place is for GOV & Non-Profit with a process performance of 2.37.

The get further insights into the outcomes of our study at DDoD, interviews were conducted. We found that all interviewees agreed that DDoD has the capabilities related to BPM Maturity level 1 (Initial). Many initiatives and improvement plans are underway independently at different levels and places within the organisation but are not coordinated top-down. BPM does not receive the same attention and seriousness as, for example, finance and purchasing, which are considered much more important.

BPM seems to be less prestigious; many see BPM as a 'necessary evil' because the DDoD rigidly handles processes. The DDoD organisation is more concerned with the judgment and recommendations of internal or external auditors and certification bodies rather than internal BPM Maturity development initiatives, an internal IT auditor stated. BPM improvement attempts are made at various places in the DDoD organisation, but they are not centrally managed and therefore are not attuned to each other. The interviewees have little faith that the BPM Maturity will ever develop beyond level 2. Some even questioned the current BPM Maturity at level 2 (Managed) derived from the quantitative study.

Secondary data collected from the DDoD intranet and databases showed that many initiatives and improvement processes are underway parallel, both decentral at the defence units and central at the defence staff. The DDoD has a vision of managing the organisation based on BPM. However, this vision is described on the strategy level and still requires translation to the practice of tactical and operational levels. Most (improvement) initiatives are initiated locally by the subdivisions without

direction or guidance from the central defence staff, corroborating the findings from the interviews. One subdivision has set up its own Process Management board. Finally, there is no complete big picture of all initiatives and BPM projects initiated at the DDoD to improve BPM Maturity.

5 Conclusions, implications, limitations and further research

This study aimed to determine the BPM Maturity and Performance of the DDoD and where it stands when it is benchmarked with similar organisations and the private sector. Except for the group of private companies (BV NL) with a BPM Maturity leaning towards level 3 (Defined), all other organisations, sectors and groups from this study have a BPM Maturity ranging between 2.56 and 2.66.

With a BPM Maturity score of 2.66 (level 2 = Managed), the Dutch Department of Defence has a ranking not much deviating from other governmental and non-profit groups studies in The Netherlands and beyond. The index score is almost similar to another defence organisation, the Peruvian Airforce, analysed by De Waal et al. (2017a).
The practical contribution of this study is that it has provided the Dutch Department of Defence (DDoD) with the first measurement of its BPM Maturity and comparison with other organisations. The DDoD can assess their BPM Maturity development strategy informed by actual data and measurements. Furthermore, we found that public and non-profit organisations consistently score lower than private (commercial) organisations. As Santana et al. (2011) and Syed et al. (2018) already showed, there are many reasons why these types of organisations are different. Still, these organisations should look at the best practices provided by private organisations to learn how to improve their BPM capabilities to increase process performance.

We have attempted to analyse the BPM maturity of a hierarchical organisation with this study. We did not select the BPM Maturity and process performance at a process level., but analysed the BPM Maturity on an organisational (department) level. The current research design looks at the maturity of all business processes. In maturity and process performance, some business processes may be far ahead of others.

This study contributes to the knowledge of BPM maturity and Process performance benchmarking of hierarchal organisations. Additional surveys with a stratified selection of respondents from various subdivisions could improve the picture on a process level rather than an organisational level. Specifically, measurement of the BPM Maturity of critical processes (at process level), equipment management process, purchasing, and maintenance are insightful and of practical contribution.

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RESEARCH IN PROGRESS

University Students' Learning in Transition: A Research-In-Progress Perspective on Internet Platform Affordances Before and During the COVID-19 Pandemic

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Abstract COVID-19 has forced universities worldwide to rapidly change their lectures to a distance setting, leaving students to a high degree on their own and engaging in informal learning. In this regard, user-generated content-based Internet platforms (UGC platforms) such as Wikipedia, YouTube, and Facebook provide users with openly accessible support for various informal learning needs. This research in progress applies a two-staged qualitative interview study with students comparing the situation before and during the Covid-19 pandemic by applying an affordance perspective. We seek to offer differential insights on perceived affordances of UGC platforms and conditions facilitating their actualization. Based on an adapted Grounded Theory-based analysis, the stage-1 interviews have already shown the viability of this analytic approach and that students perceive and actualize a range of affordances of UGC platforms. Facilitating conditions for affordance actualization embrace two main themes: default behavioral and motivational conditions. In stage 2, the results will be verified, and new insights into changes compared to the pre-pandemic state will be derived.

Keywords: user generated content, Internet platforms, informal learning, affordances theory, facilitating conditions, Covid-19 pandemic.

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1 Introduction

COVID-19 has reshaped life, also in the educational field (Marinoni et al., 2020). Before, students learned on campuses and with their peers. Suddenly, lectures had to be transferred to the online world (Zhao & Watterston, 2021), leaving students on their own to a greater extent than ever before. New ways of getting information and knowledge, communicating, and collaborating had to be found.

Prior work on higher education during COVID has emphasized challenges to teaching (e.g., Mishra et al., 2020; Rapanta et al., 2021). There seems to be a lack of research focusing on distributed, self-directed learning by students, especially regarding informal opportunities for information acquisition and collaboration. In this respect, we assume that Internet platforms like Wikipedia, YouTube, and Facebook have supported students, providing rich amounts of user-generated content (UGC) for emergent learning needs (Nagler et al., 2017). While there are critical views toward UGC usage in higher education (Pal & Chua, 2016), others see it as enrichment (Meseguer-Artola et al., 2019), promising compensation for the lack of physical closeness during the pandemic.

This research in progress seeks to analyze how UGC platforms support university students' learning through an affordance perspective. Affordances provide us with a new lens to explore emergent use of UGC platforms from the perspective of usefulness to support users' individual objectives in a particular context (Fayard & Weeks, 2014; Majchrzak et al., 2013). The particular context for us refers to alternative learning on UGC platforms in higher education before and during the pandemic. Specifically, we investigate the following research questions: (i) Which main affordances of UGC platforms have students perceived and actualized to support their learning goals before and during the COVID-19 pandemic? (ii) Which factors can facilitate (or inhibit) students' actualizing of perceived affordances in the respective periods?

Methodologically, we apply a qualitative-interpretative research strategy to discuss UGC platform use from an affordance perspective. Therefore, explorative interviews with students at different academic levels and programs were/will be conducted. Data were/will be analyzed using Grounded Theory-based techniques (Sarker et al., 2001; Strauss & Corbin, 1990, 1998).

2 Theoretical Background

2.1 User-Generated Content (UGC) for Learning

UGC platforms enable users to openly create, distribute, and consume information via various social media/web applications, e.g., Wikipedia (wiki), YouTube (content-sharing platform), Facebook (social network), Pinterest (social bookmarking), forums (information and knowledge commons) and virtual worlds (Kaplan & Haenlein, 2010; Treem & Leonardi, 2013). In this regard, the community accomplishes production and quality assurance (Yaari et al., 2011) based on the "wisdom of crowds" (Surowiecki, 2005).

Previous research has investigated students' usage of UGC platforms for academic and other purposes (Aillerie & McNicol, 2018; Nagler et al., 2017; Raith, 2019), user-related differences (Kim et al., 2013), quality perceptions (Raith, 2018; Tan, 2013), and factors driving usage (Arteaga Sánchez et al., 2014; Kim et al., 2014; Sharma et al., 2016). Most of these accounts draw on surveys.

Only a few studies used qualitative methods to explore students' motivation deeply. For example, from interviews with engineering students, Ali et al. (2017) concluded that "personality, social influence, information quality, system usefulness, and satisfaction" (p. 559) were deciding to use social media for entertainment, socializing, information sharing, and learning. Other studies reported similar results (e.g., Aillerie & McNicol, 2018; Sharma et al., 2016).

2.2 Affordance Theory

Affordances are based on the original introduction by the ecological psychologist Gibson (1977, 1979), who defined affordances as "the possibilities for action" an object or environment offers to a perceiving and goal-directed subject. The original definition differentiates between affordances and physical properties like color and form, which in our context are the features of UGC platforms. After some debate between ecological psychologists (Chemero & Turvey, 2007), the consensus is that affordances are emergent, relational properties of animal-environment systems. In our context, we define a UGC-platform affordance accordingly as "*the potential for*

action associated with achieving an immediate concrete outcome which arises from the relation between the UGC platform and a goal-oriented student user" based on Strong et al. (2014, p. 69).

To generate a concrete outcome or an effect, perceived affordances have to be actualized. The literature argues that certain conditions might foster, or impede, affordance actualization, e.g., labeled as actualization effort (Bernhard et al., 2013), potency (Anderson & Robey, 2017), or facilitating conditions (Thapa & Sein, 2018). These concepts mainly refer to the ease or difficulty an individual experiences in actualizing a perceived affordance in a given context. Thereby, lower energy requirements increase the probability of actualization (Anderson & Robey, 2017). Within this study, we use the term facilitating conditions for factors promoting affordance actualization.

3 Research Design and Methodology

The unforeseen onset of the Covid-19 pandemic allowed for a two-staged research design. Stage 1 was completed before the pandemic and includes explorative interviews with 18 students at different academic levels at WU Vienna in Austria. Stage 2 is ongoing and relates to the time of the pandemic.

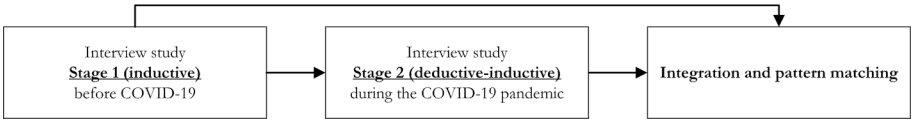


Figure 1: Qualitative and interpretative two-staged research strategy

Interviewees were/will be recruited via contacts and a mailing list and should originate from (under)graduate and post-graduate programs to gain variant views. Questions asked relate to their information sources for academic challenges, focusing on informal sources, how and why they used them—and, in stage 2, changes over time. With our last interview, we will seek theoretical sufficiency (Dey, 1999), i.e., the point at which no new topics emerge (Guest et al., 2006).

The interviews were/will be transcribed and analyzed in Atlas.ti, using Grounded Theory-analysis techniques adapted from Strauss and Corbin (1990, 1998) by Sarker et al. (2001). After bottom-up open coding, structures and hierarchies are derived

interpretively in axial coding. The authors suggest using a meta-theory to guide theory building around a core category for the final selective coding phase. In the analysis, perceived possibilities of action on UGC platforms emerged relevant, leading us to affordance theory as a basis for further development. Here, we introduced themes as higher-level categorizations for significant theory elements. Within the limits of the approach, stage 1 focused on inductive theory generation. Stage 2 will follow a deductive-inductive logic to validate the findings and explore pandemic-induced changes.

4 Preliminary Results

Figure 2 highlights the preliminary results of the first pre-pandemic stage for which Students mostly used Wikipedia, YouTube, and Facebook for academic purposes, besides lesser used platforms such as blogs, forums, and Q&A sites. Based on the data, four categories of **perceived and actualized affordances** on UGC platforms were derived:

- **Internalization affordances** refer to the possibility of acquiring information and knowledge (*"If I want to understand a new concept, I would first look at a simple explanation given in Wikipedia"*, ID18, PhD).
- **Externalization affordances** refer to the possibility of providing content, e.g., sharing one's knowledge (*"[…] somebody poses questions, and you answer them because you think: Someone must do it, why not me?"*, ID2, BA).
- **Interactional affordances** refer to the possibility to exchange with others, e.g., peer interaction and collaboration (*"[…] other students can help me when I ask […] in the group"*, ID11, MA; *"In the groups, we work on a topic together […], upload drafts of the homework […] give feedback […]"*, ID13, BA).
- **Communal affordances** refer to the possibility of connecting with others, e.g., relatedness, and collective support. (*"[…] we are all somehow equal […] people […] help each other learn. […] I do not think it would work if you had to deal with it on your own"*, ID3, BA)

Internalization affordances appeared relevant for all used platforms, while externalization affordances were, by tendency, more significant on Facebook. Interactional and communal affordances emerged for Facebook only.

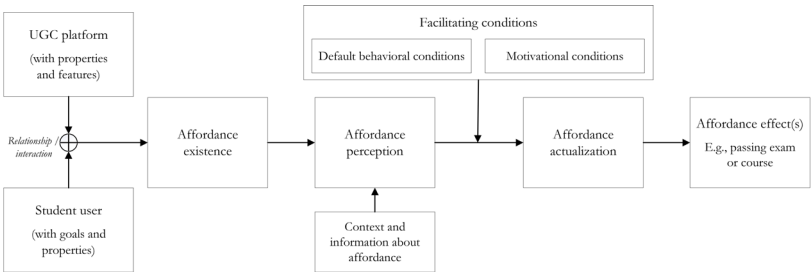


Figure 2: Affordance perception and actualization with facilitating conditions
Source: Adapted from Bernhard et al. (2013) and Pozzi et al. (2014)

Regarding **facilitating conditions** supporting affordance actualization, or impeding it in case of a negative manifestation, two main themes have emerged:

- **Default behavioral conditions** refer to students' past behavior and pressure and cues in the environment ("Wikipedia is purely a matter of habit. [...] it really is the first choice", ID1, BA; "[...] someone also said: There are videos, [where] someone explains it to you really well", ID12, BA).
- **Motivational conditions** refer to the perceived probability of expected outcomes and values attached to them, e.g., accessibility, information quality, coverage, comprehensibility, usability, efficiency, interest satisfaction ("Wikipedia because you can find [...] well researched and reasonable information on various topics [...] quickly, easily, and free of charge", ID4, BA; "[On] YouTube [...] if you have not fully understood something in lecture, it is explained in ten, 15 minutes", ID14, MA)

In terms of effects that emerge through affordance actualization, students rather reported close outcomes like mastering a task and passing an exam or a course.

5 Anticipated Contributions and Next Steps

This research in progress should enhance our understanding of how students used UGC platforms for university before and during the pandemic and facilitating conditions of such use. After stage 1, we can already report that students perceived and actualized a range of affordances for learning and academic development, and that these affordances differed by UGC platforms.

The preliminary findings are in line with previous research on affordance actualization (Anderson & Robey, 2017; Bernhard et al., 2013; Thapa & Sein, 2018) and driving factors for social media usage (e.g., Ali et al., 2017; Sharma et al., 2016), but provide a more comprehensive view, embracing two types of facilitating conditions: (1) behavioral conditions, triggered by students' past usage (habit) and their environment, playing a significant role; (2) motivational conditions, comprising the perceived quality, comprehensibility, and coverage of information, followed by convenience factors (accessibility, efficiency, usability).

In stage 2 (during the pandemic), we will seek to validate the findings from stage 1 and explore transitions of the identified themes. For example, community-based platforms like Facebook might have gained attraction to students due to social distancing. Also, perceiving interactional and communal affordances on other platforms like YouTube might have increased. Finally, other (UGC) sources could have arrived in students' informal learning like Pinterest (social bookmarking) or traditional open educational resources (OER) and MOOCs. These aspects should be examined in stage 2 based on open-ended questions, allowing us to compare the pre-pandemic with the current state and to deepen our understanding of UGC platform usage under the affordance lense.

6 Conclusions

This research-in-progress paper reported on a two-staged interview study on students' perception and actualization of affordances regarding UGC platforms for learning purposes. Stage 1 of this study showed that, before the pandemic, students perceived and actualized internalization, externalization, interactional and communal affordances to a varying degree on different platforms. The facilitating conditions for affordance actualization embraced two broad themes: default behavioral and motivational conditions. The findings from stage 2 will extend our knowledge of how these issues have developed during the pandemic.

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RESEARCH IN PROGRESS

ALGORITHMIC NUDGING FOR SUSTAINABILITY IN E-COMMERCE: CONCEPTUAL FRAMEWORK AND RESEARCH AGENDA

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Abstract This paper synthesizes relevant research fields that build the conceptual foundation of algorithmic nudging specifically for sustainability in e-commerce. The carbon footprint of e-commerce can be reduced by encouraging consumers to engage in more sustainable consumer behaviour with regards to products, packaging, delivery options, and returns. Such behaviour can be steered by employing different nudging techniques along the digital customer journey. The use of artificial intelligence can increase the effectiveness of digital nudges by tailoring them to specific individual contexts. In this article, we propose a conceptual framework for the application of algorithmic nudging to increase sustainability in e-commerce. We also derive several research avenues to spark a wide array of empirical studies to move forward this emerging topic.

Keywords: choice architecture, digital nudging, algorithmic nudging, sustainability, e-commerce.

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1 Introduction

Just recently, the Intergovernmental Panel on Climate Change (IPCC, 2022) released its sixth assessment report. The report finds that climate change is happening faster than expected and calls governments and businesses to take drastic action against it (World Economic Forum, 2022). At the same time, e-commerce is on the rise and continues its growth path. Within the last five years, the worldwide e-commerce turnover increased around 77 percent, reaching 4.2 bn USD (eMarketer and Statista, 2021). The higher rate of deliveries and returns increase the environmental impact of e-commerce (Fichter, 2003; Frei, Jack, & Brown, 2020; Mangiaracina, Marchet, Perotti, & Tumino, 2015). To mitigate the environmental consequences of e-commerce, all players in the e-commerce value chain need to collectively develop and offer more sustainable products, services, and solutions. Consumers should be encouraged and supported to select them in order to overcome the attitude-behaviour gap (Gershoff & Frels, 2015; Michels, Ochmann, Günther, Laumer, & Tiefenbeck, 2022; White, Habib, & Hardisty, 2019). Behavioural interventions such as nudges can be applied to achieve this (Rankine & Khosravi, 2021; Thaler & Sunstein, 2008). However, the potential of nudges to foster sustainability in the digital space is all but realized. Artificial intelligence (AI) can make digital nudges much more effective and thereby contribute to decrease the environmental footprint of e-commerce. The contribution of this paper is threefold. First, we synthesize relevant research fields that build the conceptual foundation of algorithmic nudging specifically for sustainability in e-commerce. Second, we propose a conceptual framework for the application of algorithmic nudging to increase sustainability in e-commerce. And finally, we derive several research avenues to spark a wide array of studies to move forward this emerging topic.

2 Background

2.1 The Evolution of Algorithmic Nudging

People face choices every day. These choices are not always guided by rational deliberations, but also by the design of the choice environment in which certain information is presented. In other words, what option we choose often depends on how the options are presented (Johnson et al., 2012). Changes in the choice architecture, so-called nudges, describe any aspect of the choice which alter people's

behaviour in a desired and predictable way without forbidding any options or significantly changing their economic incentives. Nudges involve very subtle manipulations that people often barely register, such as putting healthy options at eye level in a cafeteria to encourage healthier choices (Thaler & Sunstein, 2008). Nudges have already been employed in a variety of contexts to alter people's behaviour and there is a growing body of research proving the effectiveness of different types of nudges (Benartzi et al., 2017; Hummel & Maedche, 2019; Mertens, Herberz, Hahnel, & Brosch, 2022; Milkman et al., 2022).

In recent years, more and more decisions are being made online. The design of digital choice environments (deliberately or accidentally) influences people's choices. Digital nudges have two main advantages compared to their physical counterparts: they are easier, faster, and cheaper to implement; and can be personalized (Mirsch, Lehrer, & Jung, 2017). More specifically, digital nudges have the potential to be tailored to the digital footprint of an individual user, based on user data, context, and individual characteristics (Mirsch et al., 2017). Such algorithmic nudges, which leverage Big Data, can be very effective due to their networked, continuously updated, dynamic and pervasive nature (Yeung, 2017). Algorithmic nudging has the potential to change individuals' decisions and behaviours in a subtle way and at large scale (Möhlmann, 2021) and can potentially improve both individual and net welfare by fostering sustainable and climate-friendly behaviour. So far, multiple terms such as adaptive nudging (Burr et al., 2018), Big Data-driven nudges, hypernudging (Yeung, 2017), smart nudging (Karlsen & Andersen, 2019) or algorithmic nudging (Möhlmann, 2021) have been used to refer to these forms of nudges. In this article, the term *algorithmic nudging* will be used.

2.2 E-Commerce and Customer Journey

Not only since the COVID-19 pandemic e-commerce is on the rise. As reported by eMarketer and Statista (2021), the worldwide turnover in e-commerce has increased from 2.4 bn USD to 4.2 bn, which corresponds to an increase of around 77 percent within the last five years. Further growth of around 75 percent to 7.385 bn USD is expected by 2025. Digitalization and e-commerce have disrupted shopping behaviour (Velazquez & Chankov, 2019). The higher rate of deliveries and returns makes it inevitable to examine the resulting environmental and economic impact of ordering online (e.g., Frei et al., 2020; Mangiaracina et al., 2015). To better

understand how consumers shop online and where specific decisions are made in the buying process, it is useful to consider the e-commerce customer journey. The concept of the customer journey is based on the decision-making process and distinguishes three main phases: the pre-purchase, the purchase, and the post-purchase phase (Lemon & Verhoef, 2016; Tueanrat, Papagiannidis, & Alamanos, 2021). In e-commerce, consumers face decisions such as the choice of an online retailer, specific products, delivery option, type of packaging, and product return (Ignat & Chankov, 2020; Michels et al., 2022; Vakulenko, Shams, Hellström, & Hjort, 2019). These decisions have environmental consequences that can be mitigated by steering consumers towards choosing the more sustainable options.

2.3 Nudging Sustainable Consumer Choices in E-Commerce

Although more and more consumers hold favourable attitudes towards sustainable options, the market share of sustainable products and services remains low. Explanations for this attitude-behaviour gap are conflicting needs with regards to convenience, costs, or habits (Kollmuss & Agyeman, 2002). Digital nudging is suggested as one option to make the choice of sustainable options more convenient and to change habitual purchase behaviour (Gershoff & Frels, 2015; Michels et al., 2022; White et al., 2019). Recent research suggests that default, active choice, and self-nudges could increase the choice of more sustainable options in consumer choice areas related to delivery options, packaging, and carbon offsetting in online apparel retailing (Michels et al., 2022). Results of this research remains mixed, disconfirming (Mirbabaie, Marx, & Germies, 2021) or confirming the effectiveness of sustainability nudging (Berger, Nüske, & Müller, 2020; Fechner & Herder, 2022; Katner & Jianu, 2019; Lembcke, Willnat, Engelbrecht, & Lichtenberg, 2020). Based on the methodological approach of online experiments, these studies do not account for the potential of machine learning and AI. In fact, the use of AI to enable sustainable e-commerce practices is a neglected research area (Bawack, Wamba, Carillo, & Akter, 2022).

3 Conceptual Framework

Figure 1 depicts the proposed conceptual framework for algorithmic nudging to promote sustainability in e-commerce. The self-learning algorithm uses personalization and context-awareness to deliver nudges that are relevant to the

current situation of the consumer. That is, the algorithm recognizes which nudge could be most effective based on several individual characteristics, or *person factors* (de Ridder, Kroese, & van Gestel, 2022; Karlsen & Andersen, 2019; Matz, Kosinski, Nave, & Stillwell, 2017).

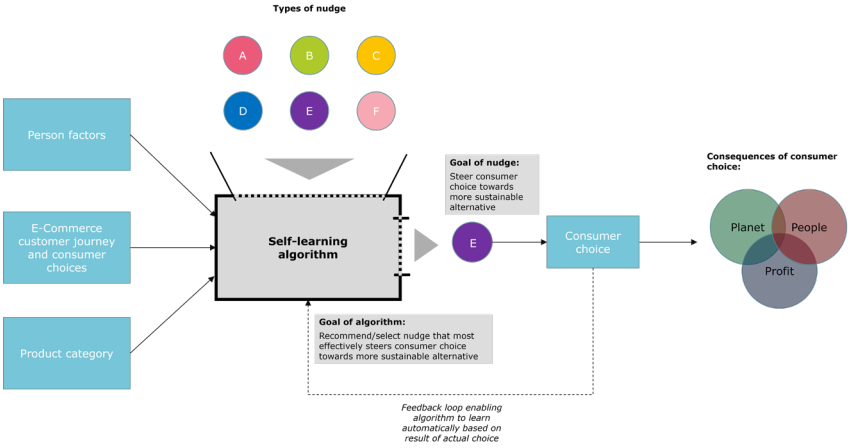


Figure 1: Conceptual Framework for Algorithmic Nudging in E-Commerce

Consumers face many different decisions along the *e-commerce customer journey*. Once consumers have selected a certain online retailer, they are confronted with decisions in four different areas (Michels et al., 2022; Vakulenko et al., 2019): (1) Products, (2) delivery, (3) packaging, and (4) product returns. An additional area is the offsetting of carbon emissions induced through a purchase which is increasingly offered by online retailers (Michels et al., 2022). Extant research on the effectiveness of digital nudging in e-commerce has considered a variety of *product categories* (Berger et al., 2020; Katner & Jianu, 2019; Michels et al., 2022; Mirbabaie et al., 2021) and has demonstrated that digital nudging can steer consumers' product choices towards more sustainable options. To effectively nudge individuals into the more sustainable direction, the self-learning algorithm must thus also learn which nudge is most effective for which product category (Shaw & Jones, 2005). There exist different *types of nudges* which can be delivered in the context of an online store. According to Jesse and Jannach (2021), four nudging types can be classified: (1) Information, (2) structure and arrangement of options (e.g., Pichert & Katsikopoulos, 2008), (3) reminders (e.g., Milkman et al., 2021), and (4) information on other consumers' behaviour (e.g., Cheung, Kroese, Fennis, & De Ridder, 2017). On these bases, the

self-learning algorithm can build up extensive knowledge about consumers and products, and incorporate the goal and the type of nudges to influence consumer behaviour (Sitar-Tăut, Mican, & Buchmann, 2021). Consumers' choices in turn feed into the system to influence the recommendations for the next nudges. Ultimately, consumer choices in e-commerce can have intended and unintended *consequences* for profit, people, and the planet (e.g., Fichter, 2003; Frei et al., 2020).

Generally, the core of debates on nudging has been the question of legitimacy: Is it admissible to subtly steer people's behaviour in a certain direction? Who determines what behaviour is desired by an individual? While nudges should be used to help people make better choices for both the individual and net welfare (Thaler & Sunstein, 2008), this has not always been the case. While unethical nudges may lead to short term gains for a company, they may backfire in terms of loss of goodwill, negative publicity, or even legal action. Especially the usage of algorithmic nudging poses ethical challenges (Möhlmann, 2021).

4 Discussion and Future Research Directions

Research on the application of digital nudging to foster sustainable consumer behaviour in e-commerce is just emerging. So far, most studies only offer fragmented insights specific to certain types of nudges and product categories. Future studies are needed to fill blind spots in the current body of knowledge. Based on our literature review and the proposed framework, we derive two broad areas for future research and several research questions (RQ) (see Table 1). The first area concerns the drivers of the effectiveness of digital nudges that are employed to steer consumer choices towards more sustainable options. The second area concerns the use of algorithms to improve the effectiveness of digital nudging. This area includes the accuracy of different algorithm types and machine learning approaches, antecedents as well as intended and unintended consequences of algorithmic nudging, the integration of algorithmic nudges in the customer journey, the legitimacy of "green" algorithmic nudges, and business model innovation opportunities.

Table 1: Research Agenda for Algorithmic Nudging in E-Commerce

RQ	Research Questions
Research Area I: Drivers of the effectiveness of digital nudges	
RQ1.1	What are relevant person factors (personality, attitudes, demographics, etc.) that determine the effectiveness of a nudge in online retailing?
RQ1.1.1	Which attitudinal factors affect the effectiveness of a nudge?
RQ1.1.2	How can attitudinal factors be derived from observable online behaviour?
RQ1.2	Which types of nudges do effectively steer consumers towards different types of more sustainable choices along the e-commerce customer journey?
RQ1.3	Which nudges work best for which product category?
RQ1.3.1	How do product category as well as packaging, delivery, carbon offsetting, and potential returns of products in this category affect the effectiveness of a nudge?
RQ1.3.2	To what extent can higher-order product categorizations influence the effectiveness of nudges?
Research Area II: Use of algorithms to improve the effectiveness of digital nudges	
RQ2.1	Which types of algorithms and machine learning approaches can most accurately recommend the most effective nudges?
RQ2.1.1	How can such algorithms provide good results with minimum vs. maximum available data?
RQ2.1.2	What drives the acceptance of such algorithmic nudges?
RQ2.2	What are the antecedents as well as intended and unintended consequences of algorithmic nudging for increasing the sustainability in e-commerce?
RQ2.3	Considering algorithmic nudges as a new type of touchpoint, how do they need to be integrated in the e-commerce customer journey?
RQ2.4	How does a "green goal" legitimate the use of algorithmic nudging?
RQ2.5	Which opportunities are there from a business model innovation perspective?

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RESEARCH IN PROGRESS

DESIGN OF A DATA ANONYMIZATION TOOL TO ENHANCE SHARING ON AN OPEN DATA PLATFORM

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Abstract Unintentional disclosure of sensitive data is a critical challenge for many organizations and a serious barrier for open data platforms. Within this research in progress paper, we propose a data anonymization tool to tackle this challenge. The goal of this paper is to elicit design requirements to increase the willingness to share data and collaborate with others on an open data platform. For this purpose, a demonstrator for a data anonymization tool was evaluated within a workshop setting with representatives from companies, science, and public authorities. We found that the willingness to share data can be increased by implementing an anonymization tool and identified further requirements to improve design and to reach the participants' involvement.

Keywords: open data, data privacy, data sharing, knowledge sharing, design science.

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1 Introduction and related work

Open data refers to the idea that collected data sets can be viewed, used, or redistributed by, e.g., collaborators on a platform (see: opendatahandbook.org). Looking at, e.g., supply chains (SCs), the volume of collected data increased intensely, by the implementation of advanced digital technologies. This results in SC partners sharing much more data with collaborators (North et al., 2019; Spanaki et al., 2018). Consequently, this increasing exchange of comprehensive data sets leads to problems like privacy issues or even knowledge risks (Spanaki et al., 2018; Zeiringer & Thalmann, 2020). Also, innovation is closely linked to the data exchange between various partners within a SC and also external partners who collaborate in open data platforms and connect public and private stakeholders (Enders et al., 2020; Zeiringer et al., 2022).

The fear to unintentionally disclose critical data and especially critical knowledge is a serious barrier for data, respectively knowledge sharing and for participating in sharing communities (Manhart et al., 2015). Data anonymization is one promising approach to mitigate this fear (Kaiser et al., 2020), and this does not only apply to personal data, but also for product data, process data or machine data, with reference to the previously mentioned SC. Looking at literature, data anonymization is a big field, but when it comes to open data platforms research is scarce and more research needed (Ali-Eldin et al., 2017). The primary goal of this research in progress paper is therefore to identify requirements for a data anonymization tool, to increase the willingness to share data and collaborate with others. For this purpose, the following RQ is addressed:

»What are design requirements for a data anonymization tool to enhance the willingness of data sharing of participants on an open data platform? «

The risk of unintentional knowledge disclosure can lead to knowledge risks. Modern data science methods make it possible to analyze large data sets, and the insights gained in this way could be misused by partners (Zeiringer & Thalmann, 2020). We want to address this problem in the context of open data platforms, which have become a common practice in public sector, but is rather uncommon to firms, especially regarding to the threats of data privacy or strategic reasons (Beno et al., 2017; Enders et al., 2020). To attract entrepreneurs to open data platforms, the

protection of data and the benefits of participation must be ensured. Data anonymization in the context of an open data platform must draw on proven concepts of anonymization in the existing literature, e.g. (Domingo-Ferrer, 2002; Drechsler, 2011; Hundepool, 2012). In the following chapters, the procedure and elaborated design requirements, based on the considerations mentioned above, are presented.

2 Procedure

2.1 Methodology

The problem of unintentional disclosure of sensitive data or resulting knowledge in the context of participating in open data platforms is examined. In a first investigation, the state of research was elaborated within a structured literature review (Zeiringer & Thalmann, 2020). In a further step, an exploratory interview study was conducted, in which various experts were confronted with this problem setting and approaches of dealing, respectively the state of risk management were deduced (Zeiringer & Thalmann, 2021).

Overall we conduct design science research (DSR) (Hevner et al., 2004) as the relevance of our research is directly related to the development of IT artefacts (Peffers et al., 2007). The basic principle in DSR is that research addresses a real world problem by designing an artifact addressing the problem followed by rigorous evaluation showing the impact for practice and theory (Hevner et al., 2004). DSR can be organized according to relevance, design and rigor (Hevner, 2007). The relevance cycle provides requirements from the environment; in our case the idea emerged out of previous workshops and interviews, in which participants have expressed the need for such a tool solution. The rigor cycle (conducted literature review) provided us with the knowledge base to theoretically design such a tool and, last, the design cycle (we present in this paper) aimed at construction and evaluation of the proposed tool (Hevner, 2007).

2.2 Tool design

For elaborating the requirements of a data anonymization tool in an open data environment, a clickable demonstrator was built. Therefore, the *Moqups* platform was used. *Moqups* presents itself as a visual collaboration tool that combines whiteboard, diagram, mockups, and design features in a single, online app. It is web based and easy to use for prototyping (see: https://app.moqups.com). Out of the rigor cycle, multiple types of data anonymization were selected upfront, checked for their feasibility, and implemented in the demonstrator for illustration purposes (see Figure 1, section 2 for selected types).

First, non-perturbative methods were consulted, which replace values of specific description with a less specific description. Two chosen examples are generalization, where individual values of attributes are replaced with a broader category, and suppression, where certain values of the attributes are replaced by, e.g., an asterisk (*) (Hundepool, 2012). Next, perturbative methods were consulted, which distort the data by adding noise, or aggregating values, or generating synthetic data (Hundepool, 2012). First method chosen was additive noise, which replaces the original value with a random added value (Brand, 2002). Second was micro aggregation, which partitions the original dataset into clusters and for each cluster, an aggregation operation is computed and used to replace the original records (Domingo-Ferrer et al., 2002). Lastly, data synthetization refers to data that is artificially created rather than being generated by actual events. Therefore, a model from an original dataset created and by using this model, synthetic data can be generated. This type of data follows the statistical characteristics of the original dataset and does not reveal data points from the original dataset. Synthetic data can either be fully synthetic, which means the entire dataset is replaced, or partially synthetic, which means that only sensitive data is replaced (Drechsler, 2011). The trade-off of privacy and utility is a known impact on the user, when it comes to data sharing, e.g. (Asikis & Pournaras, 2020). Regarding this trade-off it can be said that all methods mentioned above aim to minimize leakage of any kind of sensitive data and try to distort it just enough to keep it useful.

2.3 First demonstrator workshop

The above-mentioned methods for data anonymization aim in two directions: on the one hand, methods are used to anonymize industrial data and, on the other hand, to anonymize personal data. A first demonstration of the tool allowed the participants to get an overview before going into the discussion. Within the workshop, first the overall mission and the goal of the tool was explained to the 15 participants from business, science, and the public sector. All participants had already dealt with data anonymization in advance.

Next the demonstrator was introduced using an exemplary data set containing personal and industrial data. The data to be uploaded is displayed in a preview and the user can already edit the data here (see Figure 1, section 1). By clicking the "Privacy" button, a diagram presents that with absolutely no anonymization, the maximum utility of the data is given. By clicking the "Anonymize" button, a pop-up window appears that illustrates the different types of anonymization and actions (see Figure 1, section 2). The user now can select the approaches to anonymize the data. For each anonymization approach, the user can also change the anonymization attributes, such as the distribution type, the mean and the variance for additive noise, or the number of groups for micro aggregation. Then click "OK" and the data preview shows the first data rows, anonymized as desired.

By clicking the "Privacy" button, the trade-off that takes place between privacy protection and utility of the data (see Figure 1, section 3) is shown. If no more changes are made, the user clicks on continue and can decide in the last step whether the data should now be published or not.

After the demonstration, three rounds, with five people each, were held to discuss the demonstrator, its integration, and further requirements.

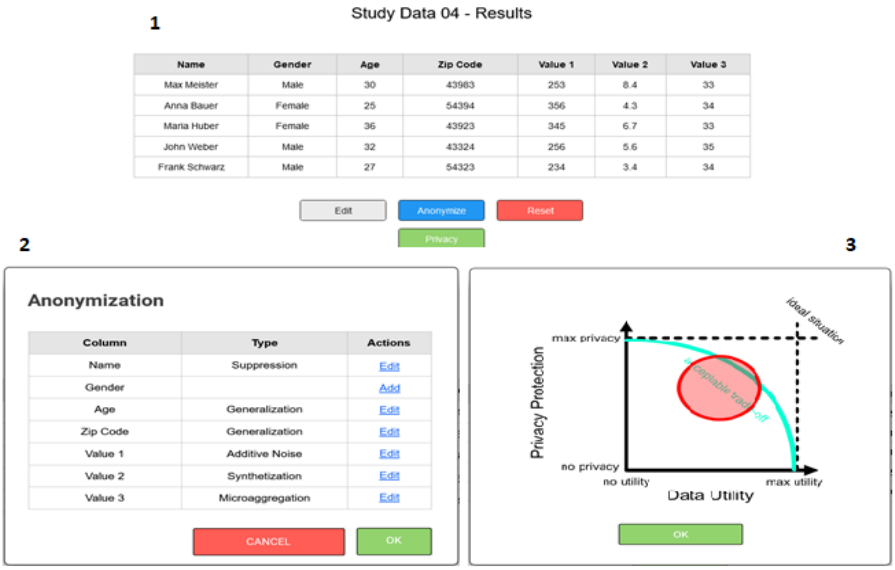


Figure 1: Screenshots of single steps in the demonstrator

2.4 Evaluation and reflections

Four main questions revolved around the integration of a data anonymization tool, for which type of data which anonymization method can be used for, how a tool affects the willingness to share data, and what crucial requirements and ideas for further development came to the participants' attention. The participants highlighted the need for a tool for data anonymization on a potential open data platform and further see such tool as urgent requirement that must be in place before they are willing to share data. Literature recommend certain anonymization techniques, especially for data anonymization prior to sharing: generalization, suppression, permutation, and perturbation (Fung et al., 2010). These techniques were discussed with the participants and considered to be useful and valuable.

Regarding the data types, the need of data anonymization for personal data was often mentioned. Further, the participants also saw uses for industrial data, as well as log data from the internet and mobile networks. These different perspectives were discussed because the workshop participants were from different sectors and dealing with entirely different data. Thus, different types of anonymizations are needed, but the users of the tool must already be trained in advance and know which type of

anonymization fits which type of data. This problem can also be found in the literature and represents a requirement that needs to be addressed in our future research (Hargitai et al., 2018).

Regarding the willingness to share data, certain requirements that clearly need to be in place were emphasized by the participants. First, the benefits must be clear, as it takes time to use. Furthermore, there must be transparency about the processing of data by the tool. Another requirement mentioned was mutuality and reciprocity of data sharing - the willingness to share increases the more people participate. Especially with regard to open data or an open data platform, the person in charge must know exactly which data can be shared without offering conclusions about e.g. internal firm knowledge (Enders et al., 2020). For further development, it was emphasized that use cases for illustration, or tutorials with exciting example data must be made accessible, to make the advantages of the tool, or its application, clear for people. Concluding, the benefit for the user must be clear and comprehensibility about the application possibilities of the different anonymization methods given, it must be free of charge, simple and quick to implement. This is consistent with the criteria listed in acceptance research, such as utility and ease of use (Alexandre et al., 2018).

3 Outlook

This research in progress paper reports on a tool that is designed for data anonymization in open data platforms. The tool aims to reduce or even eliminate data privacy threats and tackle the overall challenge of unintentional disclosure of sensitive data or even resulting knowledge. Thus, users should be able to individually anonymize data before sharing. Within workshops the demonstrator was evaluated, and requirements are elicited.

The availability of a collaborative data platform for open data, which should improve the connectivity of regional partners to international partners is essential. The development and implementation of the demonstrator based on this local open data platform is important for the connection to European initiatives, such as EOSC (see: https://www.eosc.eu/). For future research it is planned to conduct a case study and further build on the demonstrator. The following workshops will address the application of different types of data anonymization and the issue of visualizing data

privacy risks or knowledge risks and make use of user guidance and recommender systems.

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DOCTORAL CONSORTIUM

On Data Leakage Prevention And Machine Learning

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Abstract An analyst in the field of Data Leakage Prevention (DLP) usually inspects suspicious file transfers which are called events. First of all, the data in question is classified. Then, the context of the transfer is determined. After this, the analyst decides whether the transfer was legitimate or not. This process is widely known as triage. It is monotonous, costly and resource-intensive. Therefore the following question arises; could modern DLP-Software utilize machine learning algorithms in order to automate the triage process? Further, this begs the question, which structural and organisational processes are necessary inside an organisation to automate that process. In this case, it could significantly enhance the quality of DLP practices and take work from the much needed human resources in the field of IT security. Further, DLP systems (today usually used in bigger organisations) could become more attractive and more specifically affordable for small- and medium-sized organisations.

Keywords: DLP, data leakage prevention, data loss prevention, machine learning, IT-Security.

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1 Introduction

The old saying that data is the oil of the 21st century is not true of most data-sets upon closer inspection. Nevertheless, most organisations create, process or save highly sensitive data that should not be leaked by an internal or external attacker.

Ensuring the confidentiality, integrity and availability of sensitive data is the basis of IT security, which is included in the much bigger field of information security, which in turn, ensures the protection of an organisation's values and assets.

By taking a closer look at the security objective confidentiality, it quickly becomes clear that sensitive data is not exclusively exposed to risks outside of an organisation. Negligent acts and internal attacks can also lead to a data loss incident. To detect and prevent unauthorized data transfers from an employee (by accidence) or an internal attacker, Data Leakage Prevention (DLP) systems are in place.

2 Data Confidentiality

2.1 Data Classification

To protect the confidentiality of sensitive data effectively, most well-known international information security standards (e.g. ISO/IEC 27000) recommend the classification of all data that is processed by an organisation. Based on common best practices, organisations establish policies that normally differentiate between public, internal, restricted and highly-restricted data.

Further policies are typically required for handling each individual data type outlined in the previous paragraph. Those policies also commonly differentiate between Data at Rest and Data in Motion. The definition of Data at Rest (e.g. (Broadcom, 2022)) includes all data that is permanently stored, e.g. files that were stored on hard-disks or network drives. Data in Motion describes data which is in transit e.g. web-uploads, e-mails, print-jobs or file-transfers via USB.

To provide effective data leakage prevention, the described policies for data classification and data handling need to be in place. In short, they provide the necessary controls that are technically enforced by data leakage prevention.

2.2 Data Leakage Prevention

In this paper, Data Leakage Prevention is defined as the detection of intentional and unintentional violations against policies regarding Data in Motion and Data at Rest. Therefore DLP can be understood as a common task of an organization's Security Operations Center (SOC); where outgoing data is analysed against a specified set of rules.

Using complex hard- and software solutions, which are provided by a small variety of software manufacturers, is the most popular approach of detecting policy violations. Although each solution has its own strengths and weaknesses, they all provide some kind of common feature set. Furthermore they all trigger an event for each potential policy violation that is detected by the various mechanisms(AlKilani et al., 2019; Alneyadi et al., 2016; Gugelmann et al., 2015; Ouellet and McMillan, 2011; Ullah et al., 2018).

DLP Software is commonly based on one of the two following concepts.

On the one hand there is the content-based approach of detecting policy violations. It scans transferred or stored data using (partially highly sophisticated) patterns which are called rulesets. For example, an event could be triggered by specific keywords, file-types, file-sizes or renamed file-endings. A smart black- and whitelisting of the events may significantly reduce the amount of false positive events. Several or all events are determined by an analyst later. But this is also the bottleneck of the content-based approach: a lot of false positive events are generated.

To separate the wheat from the chaff, each event gets a risk-score which is calculated by a heuristic that tries to apply an appropriate risk-level. But implementing a meaningful risk-score is difficult if not impossible in practice. Because of this, the content-based approach often still results in a huge workload for an analyst. It is not unusual, that - depending on the organisation's risk appetite - the false positive rate of all the collected events far exceeds 90 percent. However, the false negative rate still remains unknown. All of this makes the content-based approach costly and resource-intensive.

An alternative approach, namely the behaviour-based approach, is often proposed to detect policy violations. Using correlations in a user's behaviour, the algorithm tries to detect anomalies which might contain a policy violation. This approach only examines the user's behaviour, while, for example, leaving suspicious e-mail-attachments out of the scope of anomalous behaviour. The disadvantages of this approach seem to be obvious: the idea of a correlation based analysis is in practice undermined by the fact that this approach tries to use correlations to detect causal links. For example, if an employee typically sends a set number of personal e-mails to a personal e-mail address each week, and suddenly this pattern changes (or not), is this truly indicative (or not) of a policy violation?

Of course, articles describing this approach(Faiz et al., 2020), where an e-mail attachment is just seen as a yes or no flag, have been shown to have some scientific backing. On top of this, well defined and barely changing processes can be protected against many cases of data leakage using this method, so it is predestined to be used in high-security environment. On the other hand, the number of processes required and the complexity of these processes is often unspecified (especially in small- to medium-sized companies), making it impossible to follow this kind of approach. So it is not surprising that the behaviour-based approach is often seen as a kind of snake oil in these environments.

Both approaches have the following in common: the decision about escalating an event as an incident to the management level or determining the final classification of an event must be undertaken by a human being. In order to be able to make an informed decision, the data in question has to be analysed, classified and set into the correct context. This process is known as triage.

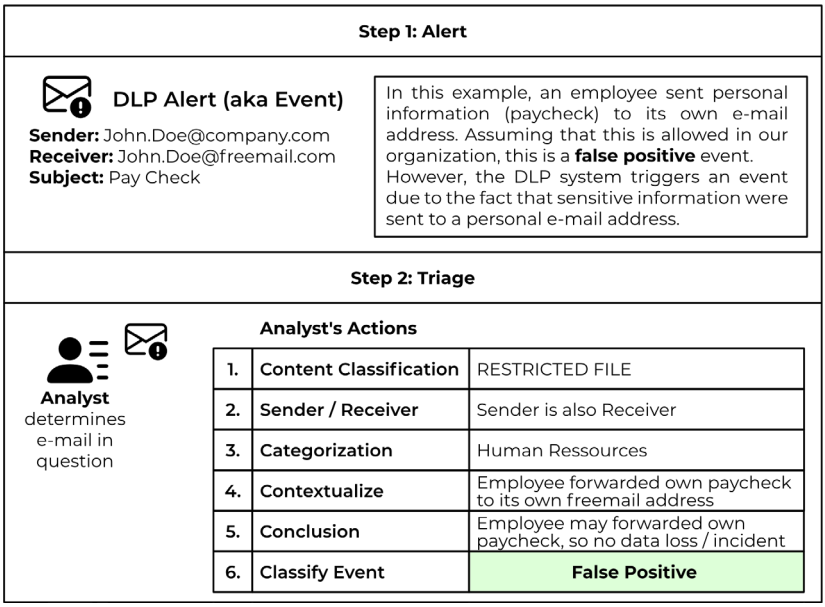


Figure 1: An example on how the triage process is performed

3 Thresholds And False Positive Events

As described, operational costs of a DLP system are not only expensive because of licensing, but also because of the resources needed for its administration. Further, each event that has been assigned a specified risk must be triaged by a human analyst.

If a company decides that policy violations should not be determined by a non-transparent algorithm, the content-based approach is often chosen for DLP activities. In this case, thresholds for the DLP rule sets have to be defined. If these rules are really strict (e.g. each E-Mail above 3 KB in size sent to a freemail account, triggers an event), lots of false positives are created. If they are less strict, the risk of an undetected DLP incident rises.

The resources needed to perform the triage are linearly increasing with the amount of triggered events. Or, in other words: The greater the DLP risk an organisation is willing to accept, the less the company will have to pay.

As noted earlier, only a few organisations have structures and processes in place that allow the automated detection of DLP incidents using heuristics. However, an automated incident detection system (or a reliable risk rating of events) can reduce DLP risks of an organisation, however, it may increase the time spent by an analyst reviewing false positive events. On top of this, DLP systems could be made more attractive for small- and medium-sized organisations which don't actually have the software, hardware and structures in place to perform a cost efficient risk treatment on DLP risks.

4 Is an automation of the triage process possible?

Regarding several data sources that could be used to apply a machine learning algorithm (e.g. organisation chart, active directory logs, e-mail history, employee address books, proxy logs, etc.), the research gap that is actually addressed is the following:

How far - and under which circumstances - can the DLP triage be automized by using appropriate machine learning algorithms?

So, in detail, the following topics are actually covered:

- Which data leakage scenarios can be detected automatically and which data sources need to be available for that?
- If not possible: How far can well established machine learning algorithms support the automation approaches?
- Which knowledge transfer methods can be used to continuously improve a DLP system as well as the surrounding processes?

5 Approach

1. **Get / Explore / Prepare a test set**. If there is no suitable DLP test set available, an training set needs to be created (e.g. from (CALO Project, 2011))
2. **Include data leakage attempts:** Put e-mails into the data set which include »normal« and advanced data leakage attempts, based on a threat model
3. **Use machine learning to perform the triage:** Retrace state of the art papers to create suitable ways to automate the triage

4. **Compare:** ...with the classic triage as it is performed nowadays

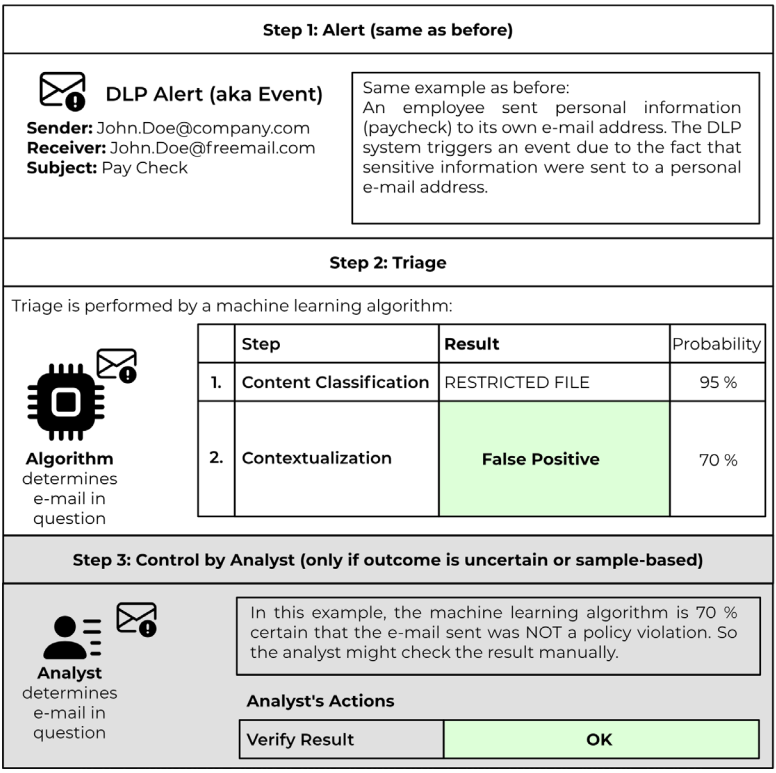


Figure 2: Research in progress - Is there an efficient way to automize the triage process like this?

6 Performance Measurement

A natural question is what would good key performance indicators (KPI's) for an automated DLP solution look like and how could they be measured against a human analyst doing the same tasks.

Regarding these questions, the general definition of the efficiency of a DLP system is determined.

Regarding the marketing slides from big vendors, the efficiency of their DLP solutions is based on a set of innovative features. However, in practice, the effectiveness of many security systems (e.g. firewalls or intrusion prevention

systems) correlates strongly with its configuration. It seems logical, that highly sophisticated and well maintained rule sets are often more effective than outdated pre-sets, provided by a vendor. Assuming that a well configured DLP environment is in place, the efficiency of the described, automated approach will be assessed by the risk rating or classification of the data that was reviewed.

In many DLP studies (e.g. (Huang et al., 2018)), algorithms are tested against test sets that are publicly available on the internet (e.g. (Lewis et al., n.d.)). This leads to indicative studies from an academic point of view. But algorithms that work on generic test sets do not necessarily work in a complex organisation, where personal - and business e-mails are often mixed up and languages vary. However, these »exceptions« are precisely where bottlenecks in modern DLP system occur, causing several false positive events as described earlier.

To give an example, newspaper articles make a brilliant test set for testing the classification skills of a machine learning algorithm. Although this of course has nothing to do with the data that will be classified by a DLP analyst who will, for example, search through suspicious web uploads with obscured, highly sensitive data.

To be able to see if an automated, contextual classification can compete with an analyst's work, it seems indispensable that a set of test data, that mimicks typical office communications, but contains clear security violations must be created, geathered and / or generated.

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DOCTORAL CONSORTIUM

DECISION SUPPORT FOR RISK MANAGEMENT IN HEALTHCARE ORGANISATIONS

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Abstract Poor quality of healthcare is a cause of needless mortality. Therefore, quality management in healthcare organisations is an important component of modern clinical practice. This paper focuses on risk management and, in response to flaws of the current approach, presents a novel strategy to improve risk level evaluation in healthcare organisations. A multi-attribute decision model for evaluating the level of risk in healthcare organisations was developed using the DEX method. The decision model addresses the shortcomings of the currently accepted and commonly used risk matrix approach. The developed model strives towards improved resolution and decreased bias of evaluators, to provide a transparent and objective method of evaluating the level of risk in healthcare organisations. It consists of eleven basic and seven aggregate attributes that are hierarchically structured and related with predetermined simple if-rules. The evaluated level of risk is derived from two main aggregated attributes based on the existing risk matrix - probability and severity of impact. The main advantage of the presented decision-making model is the consideration of various aspects of risks to promote a holistic, transparent and objective risk evaluation process.

Keywords: risk management, DEX method, risk matrix, quality management, healthcare.

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1 Introduction

Adverse events and medical mistakes are major causes of mortality in healthcare. American research ranks mortality due to medical mistakes as the third leading cause of mortality, estimating that a lethal medical mistake occurs in 0.71 % of hospitalizations (Makary & Daniel, 2016). Similarly, the World Health Organisation estimates that one in ten hospitalised patients are exposed to poor quality of health care and suffer related negative consequences (World Health Organisation [WHO], 2014). Since the poor quality of care is directly related to increased mortality (Kruk et al., 2018), maintaining the adequate and improved quality of care is an important goal of healthcare organisations and healthcare systems. Achieving adequate health care quality requires appropriately skilled healthcare professionals who strive to maximise efficiency and minimise patient risk while providing safe, patient-centred, timely, and equitable patient care (Seelbach & Brannan, 2021).

The most basic analysis of quality can be achieved by collecting data regarding the main quality indicators, which include mortality, disability, resolution or persistence of disease following treatment, discomfort and patient experience (Seelbach & Brannan, 2021; White, 1967). Similar approaches were taken in Slovenia when The Medical Chamber of Slovenia introduced the implementation of some basic quality indicators in 1998 (Lainščak et al., 2022). Development in the field of quality management continued more intensively in 2010 when the first national strategy for quality and safety of healthcare in Slovenia was developed (Simčič, 2010). Quality management is now an important part of modern healthcare practices. Within the strategic approach of total quality management, it strives toward continuous improvements, teamwork and customer focus (Dean & Bowen, 1994), while incorporating various approaches for quality improvement and monitoring, which include internal and external audits, accreditations, certifications, licensing, incident reporting and risk analysis (Lainščak et al., 2022). Our research will focus on risk management in healthcare organisations.

Risk is an effect of uncertainty on objectives, where this effect is a deviation from the expected. The effect can be positive, negative or both, and can address, create or result in opportunities and threats. Risk management is a set of coordinated activities to direct and control an organisation regarding risk (International Organization for Standardization [ISO], 2018). Approach to risk management can

be either reactive (incident analysis) or proactive, meaning organisations identify risks in advance – before they recognize the effect of uncertainty in clinical practice (Preliminary Hazard Analysis, Root Cause Analysis, Failure Mode and Effect Analysis and similar methods) (Prijatelj, 2012; Simsekler, 2019). Risk management is especially present in high risks industries (Prijatelj, 2012) and includes three main phases: risk identification, risk analysis and risk evaluation (International Organization for Standardization [ISO], 2018). Our research will further focus on risk evaluation in healthcare organisations.

A common approach for risk evaluation in healthcare organisations is the use of the risk matrix. The approach is based on a graphical representation of the two main variables needed to determine the level of risk – probability and impact severity (Duijm, 2015). The risk matrix was first used in aviation where each risk was rated on a five-point scale for the probability of the event and a five-point scale for severity of impact (Garvey & Lansdowne, 1998). An example of a four-point scales risk matrix is presented in Figure 1. The calculated level of risk is presented in the body of the risk matrix and is calculated as *Level of risk* = *Probability* × *Severity*.

		Severity			
		1 - negligible	2 - low	3 - severe	4 - catastrophic
Probability	1 - improbable	1	2	3	4
	2- remote	2	4	6	8
	3 - likely	3	6	9	12
	4 - frequent	4	8	12	16

Figure 1: Risk matrix

Following modifications of the risk scale allowed this approach to be applied to diverse fields. In addition to scales changes, the variables of the risk matrix were adapted to better describe the evaluated risk. An example of this is a risk matrix combining the features of plants and different herbicides to describe the level of herbicide resistance development risk (Moss et al., 2019). Similarly in healthcare, the risk matrix was modified so it could be used to evaluate the risk of contracting the Covid 19 infection. In this case, the matrix derived the final estimate of risk based on the nature and duration of interpersonal contact (Williams et al., 2021).

The risk matrix is widely applicable and easy to use. The approach is also used in healthcare, where the use of probability and severity of impact variables can be used to evaluate diverse risks associated with healthcare organisation management and patient care. Evaluation of such risk is important since it ensures the framework for comparison of detected risks and is the basis for management of risk, planning and establishing priorities in corrective measures implementation (Pascarella et al., 2021). Nevertheless, the approach is not without faults. Cox (2008) points out that the main faults of the risk matrix are poor resolution, the ambiguity of inputs and outputs and proneness to error. The approach does not ensure the minimization of bias by the person evaluating the probability and severity of impact (Smith et al., 2009). Furthermore, the risk matrix is not transparent. In-depth interpretation of results or comparison of evaluated risks is not plausible without explanation, which is rarely provided in practice and not quarantined by the approach (Cox, 2008).

Subjective bias in risk evaluation is an important weakness in risk management, especially if risks are not evaluated by the same person. This is often the case in healthcare organisations as risks are evaluated by different evaluators from diverse clinics or working environments within the institution. Second, transparency of the decision process is vital for further investigation of the evaluated risk, since reasoning for the evaluated level of risk is crucial to consider when choosing appropriate correction measures. That is why in our research we aim to decrease the evaluator bias in evaluating risks to promote more accurate risk comparison and support appropriate organisational response. Furthermore, the existing risk matrix is categorised as a qualitative risk evaluation method (Bower-White, 2013), however, its design more accurately provides a rough discrete approximation to an underlying quantitative relation, which can be inaccurate (Cox, 2008). We wish to design an improved model for evaluating risks that are based solely on qualitative evaluation and ordinal categorisation of risks to achieve the most accurate, adaptable and easy to understand approach to evaluating risks, suited for use in diverse modern healthcare organisations.

2 Methods

DEX method was used for the development of our decision model. This method was chosen based on our familiarity with the approach and its previous application for similar decision problems support in healthcare and other fields (Boshkoska et al., 2020; Erdogan & Refsdal, 2018).

DEX (Decision Expert) is a method for multi-criteria decision modelling that dates from the year 1980. It represents a fusion of multi-criteria decision-making and artificial intelligence (Bohanec, 2022). DEX method belongs to the multi-attribute utility theory, where the attributes are defined with qualitative value domains consequently classifying the alternatives. Attributes are arranged hierarchically. Values of hierarchically lower attributes are used to determine the values of hierarchically higher attributes. Evaluated options are described in hierarchically lowest basic attributes. The values of hierarchically higher aggregated attributes are calculated according to their predetermined utility functions, which are presented as a set of simple if-then rules. Weights of attributes are not pre-fixed but may depend on the values of attributes as each rule can be independently altered. For example, a very negative value may be more important than positive values of the same attribute. This is a benefit of this approach in comparison to the usual weighting sum models. This methodology is included in a Microsoft Windows-based software titled DEXi, that was used for model development (Bohanec, 2021; Bohanec et al., 2013).

A preliminary review of the literature was undertaken to identify the most crucial studies and guidelines related to risk management practices in healthcare organisations. Using clinical knowledge, information gained was synthesized into a multi-attribute decision model using DEXi software. The selection of two main aggregated attributes was based on the risk matrix, which is a common contemporary approach for risk evaluation. Additional attributes were enlisted based on the preliminary literature review and clinical experience regarding risk evaluation.

3 Results

The designed multi-attribute risk assessment model consists of two main aggregated attributes – Probability and Impact severity. Hierarchically highest aggregated attribute- Risk level is representing the evaluated level of risk and is the final result of the decision process. Hierarchically lower aggregated and basic attributes of the decision model can be visualized as a tree of attributes, which is presented in Figure2.

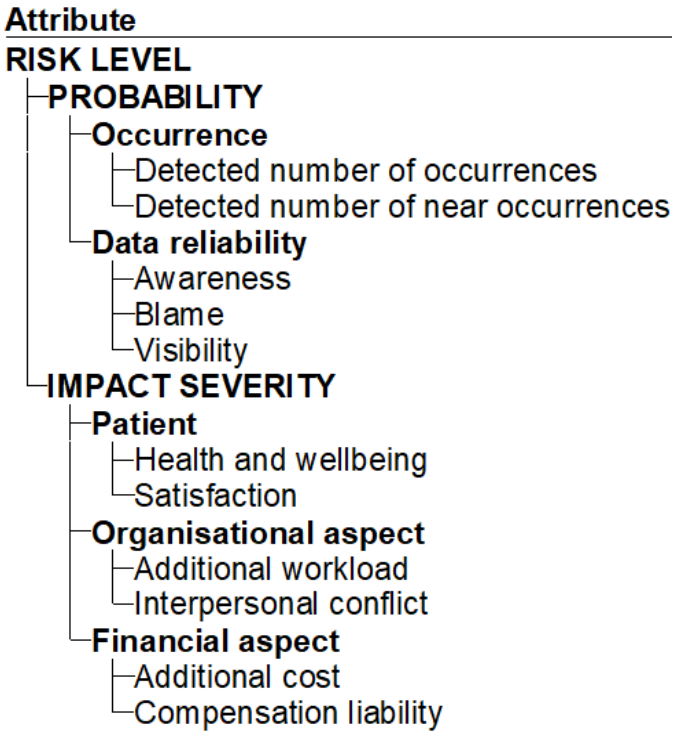


Figure 2: Tree of attributes

The model differs from the risk matrix approach in the way that it expands both main attributes relevant to evaluating risk levels. Each option is described with all basic attributes guiding the evaluator to perform a more thorough evaluation of risk.

As an example, we present a hypothetical evaluation of aggregated criteria Impact severity for a risk of a patient developing a severe pressure ulcer. As presented in Figure 3. The model evaluated the impact severity of a severe pressure ulcer as

moderate, considering not only the impact on the patient's health and well-being but also the organisational and financial aspects of the event.

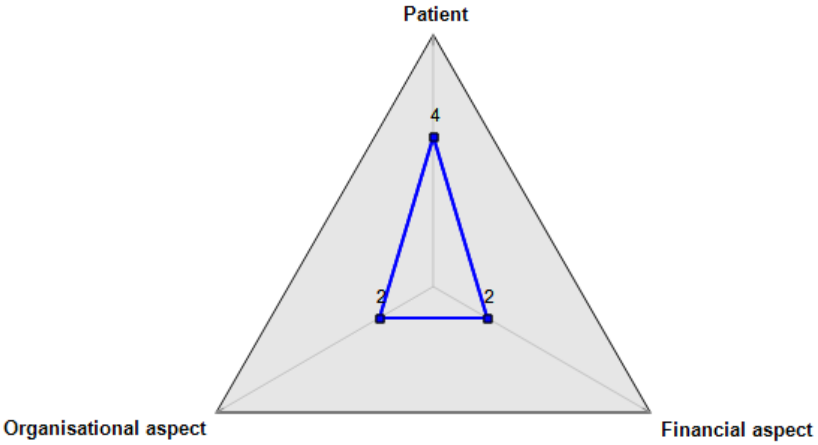


Figure 3: Example of graphical representation of values for a selected option for three chosen criteria

Relations between basic and aggregated attributes are established with utility functions as not all attributes contribute to the estimated level of risk equally. Utility function distribution is presented in Figure 4.

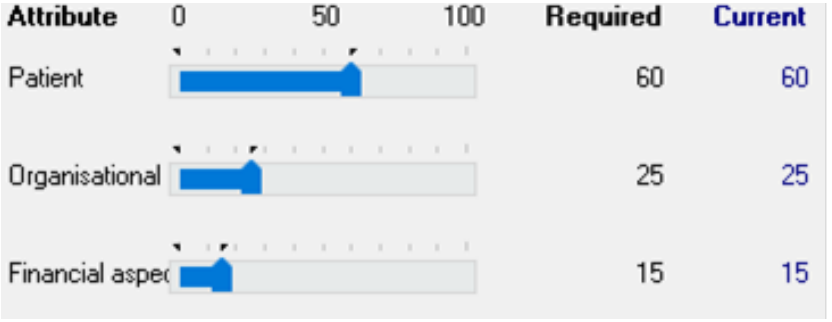


Figure 4: Defining weights of subcriteria in DEXi

Utility functions for individual attributes were assigned according to literature, clinical experience and institutional goals. In our distribution, consequences related to patient's health and satisfaction contribute most, the organisational impact of consequences less and the financial aspect the least.

4 Discussion

The presented model improves the comprehensiveness of the risk evaluation process and reduces evaluator bias in comparison to the contemporary used risk matrix. The model accounts for multiple attributes when evaluating the level of risk, enabling a more systematic and complete determination of impact severity and probability. Evaluator bias is decreased with an expansion of the evaluated attributes. The specific design of basic attributes and their domain values promote a more accurate and consistent description of risk characteristics. The benefits of using multi-attribute decision support are evident in the representation of impact severity evaluation of the presented model. The aggregated attribute Impact severity consists of three hierarchically lower aggregated attributes and six basic attributes. This leads the evaluator to consider a different aspect of an event that can contribute to the impact factor severity of the evaluated risk, besides its impact on the patient's health and well-being to promote holistic evaluation of impact severity and decrease evaluator bias.

The organisational aspect attribute consists of two basic attributes – Additional workload and Interpersonal conflicts. Additional workload is an important problem facing modern healthcare. Besides staff shortages, inadequately designed work processes and poor work organisation can contribute to a workload increase (Robida, 2009). Adverse events can further increase workload because they often require repeated clinical interventions or the performance of even more complex interventions to mitigate the consequences of the event. Quality management strategies should focus on decreasing the unnecessary workload as work overload can lead to the more frequent occurrence of adverse events (Farid et al., 2020) or even exacerbate staff shortages as an overwhelming workload can lead to termination of occupation (Holland et al., 2019). Good interpersonal relationships and communications also importantly contribute to overall staff satisfaction. That is why an aggregated attribute Interpersonal conflict is added as an influence to risk impact facto evaluation. Research in this field shows that a significant share of

reported incidents in healthcare are related to work-related communication and relationships (Jerng et al., 2017) and is therefore important to consider when evaluating the level of risk.

Although all previously defined contributors to the criterion Impact severity have direct or indirect financial consequences, the financial aspect of risk was included independently in our decision model. The reason for this is that some risks have an exclusively financial impact and do not manifest themselves as negative effects on patients' health and well-being or organisational consequences. An example of this type of risk is inadequate management of medical and pharmaceutical waste (Agrawal et al., 2017; Vaccari et al., 2018). Similarly, the attribute Compensation liability could be adequately represented in the attributes described above in examples like surgical errors, misdiagnosis, negligence etc. Nevertheless, a higher liability for compensation greatly increases the overall impact and should be considered in the evaluation. Furthermore, in the example of personal belongings misplacement, no patient-related or organisational aspect related harms occur. In this case, the included basic attributed can be utilized to adequately define the impact severity. To better represent the benefits of including these attributes in the decision process we presented an evaluation of a hypothetical risk in the results section. The impact of a pressure ulcer is not limited to patients' health, but also leads to some additional costs and organisational disturbances (pressure ulcer dressings, additional workload, and prolonged hospitalization). Using all three aggregated attributes, the presented model can adequately consider these factors in the final level of risk evaluation.

An important limitation of our research is the lack of empirical evidence to support the validity of the decision model. Future validation of the model should be focused on obtaining empirical data that can provide a rational basis for formulating appropriate decision rules. Empirical research could also reveal attributes that should be additionally included in our decision model or eliminate those that are not appropriate or useful. This could alter the structure of the proposed model to ensure results that are more valid. The benefit of using the DEX method is its adaptability as individual decision rules and the resulting relationships with included attributes can easily be modified and adapted to best describe future empirical findings.

3 Conclusion

The presented decision model can improve the objectivity, completeness and transparency of the risk evaluation process in healthcare organisations. Future empirical research should take place to analyse the validity of the proposed model and incorporate necessary modifications into the decision model.

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DOCTORAL CONSORTIUM

ENTERPRISE ARCHITECTURE FOR NETWORK ORGANIZATIONS: A RESEARCH DESIGN TO INVESTIGATE WHAT ELEMENTS OF EA HELP TO REDUCE ADMINISTRATIVE BURDENS IN HEALTHCARE

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Abstract Healthcare organizations operate within a network of governments, insurers, inspection services and other healthcare organizations to provide clients with the best possible care. The parties involved must collaborate and are accountable to each other for the care provided. This has led to a diversity of administrative processes that are supported by a multi-system landscape, resulting in administrative burdens among healthcare professionals. Management methods, such as Enterprise Architecture (EA), should help to develop and manage such landscapes, but they are systematic, while the network of healthcare parties is dynamic. The aim of this research is therefore to develop an EA framework that fits the dynamics of network organizations (such as long-term healthcare). This research proposal outlines the practical and scientific relevance of this research and the proposed method. The current status and next steps are also described.

Keywords: network governance, enterprise architecture, dynamic context, long-term healthcare, administrative burdens.

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1 Introduction

Administrative burdens in Dutch healthcare have been increasing for decades, despite all initiatives to reduce them (Veenendaal et al., 2008; Joldersma et al., 2016; Ministry of VWS, 2018; Lint, 2019; Hanekamp et al., 2020; Keuper et al., 2022). Foreign healthcare institutions face the same problem (Cebul et al., 2008; Brown et al., 2021; Chernew & Mintz, 2021). This has a serious negative impact on the functioning and satisfaction of healthcare staff (V&VN, 2019) and is one of the most frequently cited reasons for resigning (Ahli, 2019).

Administrations support the need for cooperation and accountability between healthcare management and its stakeholders (Oude Vrielink et al., 2009). The stakeholders of Dutch healthcare management are:

- *The healthcare professional,* who see the usefulness and necessity of the administrative activities, as long as they are directly related to the care of the client and registration systems are fit for purpose and easy to use (Bronkhorst, 2019; Michel, 2017). Healthcare management determines which administrative activities are carried out by the healthcare professionals.
- *The client, and its relatives* for whom healthcare is all about (Koopmans et al., 2015). In many cases the client has multiple illnesses (multimorbidity). In order to best assist the client in coping with multimorbidity, healthcare professionals need to work together and exchange information in dynamic networks.
- *The government,* which strives for public value through legislation and regulations (Jørgensen & Bozeman, 2007; Steen, 2019), from which administrative burdens arise (Maris et al., 2021).
- *Market(-forces),* which have resulted in parts of healthcare being standardized and specialized (Varda, 2011). In combination with the various laws and regulations and multimorbidity, this has resulted in a complex reimbursement structure and therefore complicated accountability to fellow healthcare organizations, healthcare insurers and governments (Ministry of VWS, 2020).
- *Inspection,* who monitors the quality, safety and accessibility of healthcare on the basis of the healthcare administrations. Additional administration may be required for the inspection due to external variables, such as an infectious disease, research results, or technological innovations (Kenis et al., 2019).

So healthcare is organized in a network of various parties that are related and accountable to each other. Due to the dynamics of the care to be delivered to the client and due to external variables such as legislation and regulations, a pandemic, research results and technological innovations, the cooperation structures between the stakeholders are constantly changing. Governing such an environment is also referred to as network governance (NG) (Berthod et al., 2017).

The result of the collaboration and accountability relationships mentioned is that they work with a diversity of automated administrations, a multi-system landscape. Enterprise Architecture (EA) is a management and technology practice to have and hold a holistic and integrated understanding of such landscapes in terms of strategic direction, business practices, information flows and technological resources (da L. Júnior et al., 2021), with the aim of optimally aligning them. Nowadays a broad variety of EA frameworks exist and are applied in the healthcare sector (da L. Júnior et al., 2020, 2021). In addition, EA is an emerging topic of research in healthcare (Wichmann & Wißotzki, 2019).

2 Problem definition

EA frameworks are based on the assumption that strategy is plannable and that multisystem landscapes can be developed and managed systematically to contribute to organizational strategy (Winter et al., 2010). Mintzberg et al. (1998) distinguished ten 'schools' of thinking about strategy. Only three of them are based on a plannable enterprise. The other seven schools of thought regard strategy more as continuous development in a dynamic organizational context. The perspective of these seven schools and the observation that collaboration and accountability in healthcare require dynamic NG makes the assumption behind EA frameworks even more questionable. This is in line with the conclusions of Lapalme (2012), Muller et al. (2013) and Kotusev et al. (2020).

In most organizations, EA frameworks will not align with organizational strategy (Kotusev et al., 2020). Current EA frameworks have limitations within dynamic contexts (Nouwens et al., 2022), such as healthcare. Lapalme et al. (2016) and Nouwens et al. (2022) see possibilities with EA to manage multisystem landscapes in such contexts and describe possible solutions and challenges. However, they do

not demonstrate whether these are effective in terms of reducing administrative burdens.. The research question of this study is therefore: *What elements of EA frameworks help to manage a multisystem landscape in order to reduce administrative burden within (healthcare) organizations with a network governance structure?*

As mentioned is the healthcare sector organized in a network structure. Most administrative burdens within the healthcare sector are experienced within long-term care, such as mental health care, care for the disabled and nursing and home care (Bronkhorst, 2019). On average 40% of the available time in long-term care is spent on administrative activities related to laws and legislation (Hanekamp et al., 2020; Maris et al., 2021). Together with the fact that long-term care is confronted with a complex reimbursement structure and therefore complicated accountability to health insurers and governments (Ministry of VWS, 2020), the long-term care has been chosen as the most appropriate research context focus for now.

3 Methodology

The research question is divided into four sub-studies. Each sub-study has its own question:

S1: Which elements of EA frameworks are related to the characteristics of NG?

S2: What are the most relevant elements of EA frameworks derived in S1 for EA architects of organizations operating in a NG context?

S3: Which EA based actions lead to a reduction of administrative burdens in long-term care?

S4: Which EA framework elements lead to a reduction of administrative burdens within a NG context?

The study is designed (Figure 1) in such a way that the results of each sub-study are analyzed chronologically and serve as input for the next sub-study.

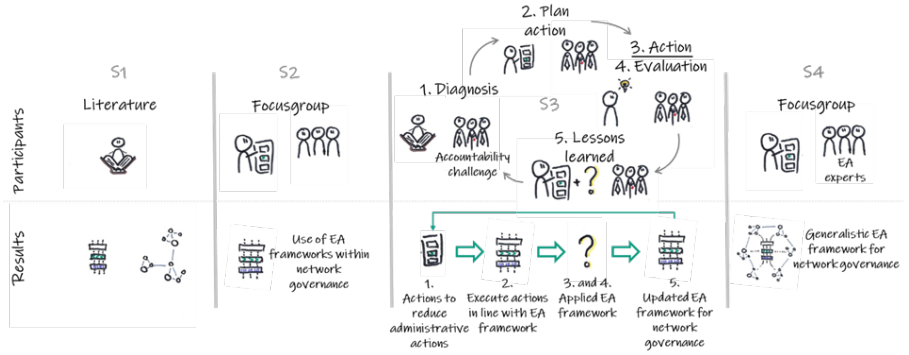


Figure 1: Research design

Study 1: *EA framework elements related to characteristics of network governance*

To reveal the elements of EA that are related to the characteristics of NG a structured literature review (SLR) (Denyer & Tranfield, 2009) will be performed. This method helps to uncover the known (international) evidence, confirm current practices, address variations and identify areas for future research (Munn et al., 2018). Denyer & Tranfield (2009) suggest that SLRs in management and organization studies should be tested for their transparency (which processes and models are employed), inclusivity (what are the inclusion/exclusion criteria), explanatory (how are the individual results combined into one story) and heuristic nature (the output may help managers, but shall not be the truth or valid evidence).

The process that will be applied is as follows: Together with a SLR expert and a short exploratory study, meta search terms and relevant databanks will be chosen to use in creating the search strings for relevant EA and NG articles. After the search results are retrieved on one particular day, the duplicates are reduced according to the protocol of Bramer et al. (2016). The search results are then assessed for relevance on title, abstract and keywords.

In order to minimize possible bias from researchers, this is done by at least two people and with the help of Rayyan (Johnson & Phillips, 2018). Conflicting articles will be discussed with the aim of reaching consensus.

The inclusion criteria for this assessment are: no foreign language instead of Dutch, English and German, peer-reviewed journal/conference article or dissertation, and the article is useful to answer (one of) the following questions:

1. What is the definition of EA and NG?
2. What is the history of EA and NG (in healthcare)?
3. What are the known benefits/success factors of EA?
4. What are the known characteristics of NG?
5. What factors of EA are related to the characteristics of NG?

The articles included are then plotted in a citation network using Gephi and VosViewer to gain insight into the most cited articles. Together with the amount of articles by the author, background author and journal/conference rating of the article, the most relevant articles will be selected for the full paper review.

The results are combined with Atlas.ti. All articles are grouped first into 'literature reviews', EA, NG and 'exclude'. Subsequently, the full text per group will be scanned and coded via open coded techniques.

The output of this sub-study will be a list of EA elements related to the characteristics of NG.

Study 2: *The most relevant elements of EA frameworks in a NG context*

A focus group is used to examine how current EA frameworks are deployed within an NG environment and to identify the most relevant elements of EA frameworks derived in S1 in a NG context. The focus group participants will be Enterprise Architects working in Dutch public organizations dealing with NG.

A focus group combines interviews, participant observation and group interaction (Plummer-D'Amato P, 2008; Luke & Goodrich, 2019). This sub-study focuses on how architects work with EA frameworks in a NG context and what support and limitations they experience from the EA methodologies. By involving several architects at the same time and confronting them with issues from a NG context, various application possibilities are brought to light and discussed directly by the participants. The interaction between participants can provide additional insights that might not be revealed during an interview.

Based on the output of S1 and the results of S2, a list of possible EA best practices in an NG context will be composed.

Study 3: *EA based actions related to a reduction of administrative burdens*

Most available EA publications, in turn, are non-empirical, although the use of empirical methods in EA research is increasing (Kotusev, 2017). Empirical knowledge development at the interface of EA and administrative burden reduction is lacking, in general and in long-term care. That is why in this study the sub-question '*Which EA based actions lead to a reduction of administrative burdens in long-term care?*' will be answered by means of three action studies that connect to each other. The aim of action research is to influence the nature of organizations and the professionalism of those involved during the research, so that changes are immediately realized and take root through a thorough evaluation and recording. Knowledge is built up on the basis of evaluation of actions. This action research therefore aims to develop knowledge and contribute to solving the acute need for administrative burdens in healthcare at the same time.

This study consists of three action studies in three different care organizations within the long-term care sector of the Netherlands. Based on the phasing of Susman and Evered (1978), the following approach has been determined that applies to each healthcare organization:

Diagnosis (identifying or defining the problem): Together with the care management of a long-term care institution, an accountability challenge related to network governance is formulated.

Action planning (weighing alternative actions to solve the problem): together with the care management, based on the EA insights from studies 1 and 2, possible actions and approaches are determined that could work.

Take action (select a method): The action that is most promising and feasible according to the care management will be carried out together with the care management.

Evaluate action (study the consequences of the action): The consequences of the action are evaluated together with healthcare management and involved healthcare professionals. The reflection will focus on the way in which the action has been carried out, to what extent the result has been achieved and whether the administrative burden has been limited (has the problem been solved) and to what extent the action has contributed to this (relevance of the action).

Specify the teaching (identify general findings): The approach chosen will be discussed with care management. If necessary, the chosen approach is refined, so that it is ready for the next accountability challenge and a common way of working within a network governance context is discovered.

In order to measure the impact of the actions on the administrative burden, a survey is sent out to the stakeholders who are directly part of the accountability challenge before and after the action research.

To guarantee the quality of this study, the five quality principles of Action Research (Davison et al., 2004) are used:

- the principle of the researcher-client agreement;
- the principle of the cyclical process model;
- the principle of theory;
- the principle of change through action and
- the principle of learning through reflection.

Each principle has its own set of quality criteria. In broad terms, this means that a researcher-customer agreement will be drawn up for each healthcare organization that participates in this study. This agreement includes the goal (solving the accountability challenge), the research method to be followed (five steps of action research), the parties involved with their role and responsibility, the duration of the research and the evaluation criteria. This ties in with the first principle. The second principle is aimed at going through the phases of action research in a structured way, as already explained. As indicated, actions are determined based on the EA insights to solve the accountability challenge. These insights are based on the results of the structured literature review (S1) and discussed with EA experts from the field through the focus group (S2). This is in line with the third principle.

The aim of action research is that a change will occur through an action (fourth principle). Ultimately, this action and the approach followed will be evaluated with those involved within the care organization. These reflections ensure that what has been learned is also recorded which is of added value for science (5th principle).

To minimize possible researcher bias, the researcher will only share the insights of S1 and S2 before the planning action phase. The care managers then choose the approach that suits them best and implement it themselves. After a predetermined period, the chosen approach and implementation will be evaluated by the care managers. The researcher will observe all phases. The results will be input for fine-tuning the insights of S1 and S2. That in turn is input to take on the next organizational challenge.

Study 4: *Focus group*

In order to place the results of the third study in a broader context, a focus group will provide an answer to the fourth sub-question ' *Which EA framework elements lead to a reduction of administrative burdens within a NG context?'* from Enterprise Architects who work in organizations dealing with network governance. The set-up of this focus group is similar to the focus group of the second study. The outcomes of this focus group will contribute to the generalizability of the EA framework properties retrieved in the action research phase.

4 Preliminary results

This investigation started at the beginning of 2021. In collaboration with an SLR expert, an exploratory study was conducted with which a search string was drawn up for EA and NG in a healthcare environment. Possible keywords and meta terms were derived from relevant (structured literature) research papers and tested. This process resulted in two searches, one for EA (Example 1) and the other for NG (Example 2).

Example 1: EA search string for Cinahl

S1 TX ((Enterprise N1 Architect) OR Togaf OR Feaf OR Archimate OR (Service N1 oriented N1 Architecture) OR ((Zachman OR Pulkkinen OR Schekkerman) N1 Framework*) OR (((Architect* N1 Framework*) OR (Organisational N1 Architecture)) AND (Health* N1 System*)))*

Example 2: NG search string for Cinahl

S1 TI ((network OR collaborat* OR cooperat* OR multisector* OR intersector* OR partnership* OR (multi N1 stakeholder*)) N1 (governance* OR governing)) OR AB ((network* OR collaborat* OR cooperat* OR multisector* OR intersector* OR partnership* OR (multi N1 stakeholder*)) N1 (governance* OR governing)) OR SU ((network* OR collaborat* OR cooperat* OR multisector* OR intersector* OR partnership* OR (multi N1 stakeholder*)) N1 (governance* OR governing)) OR KW ((network* OR collaborat* OR cooperat* OR multisector* OR intersector* OR partnership* OR (multi N1 stakeholder*)) N1 (governance* OR governing))*

S2 TX "lead organization-governed"

S3 TX "participant-governed"

S4 TX "network administrative organization"

S5 TI (health N1 (system OR sector) N1 governance) OR AB (health N1 (system OR sector) N1 governance) OR SU (health N1 (system OR sector) N1 governance) OR KW (health N1 (system OR sector) N1 governance)

S6 S1 OR S2 OR S3 OR S4 OR S5

Both searches were conducted on June 30, 2021 in six different databanks (Table 1). To be as complete as possible, both searches also included the first 200 hits from Google Scholar. Because EA is a specific IT-based concept, the databases ACM, AIS and IEEE were also included in the search.

Table 1: Search results

Databank	Amount EA	Amount NG
ACM	53	
AIS	266	
BSU	142	244
Cinahl	270	357
Embase	331	451
IEEE	24	
Medline	343	521
PsycInfo	115	418
Web Of Science	230	598
Google Scholar	200	200
Total	1974	2789

Next step was to reduce the duplicates. This was done in the week after the search was conducted. Based on seven rounds (Bramer et al., 2016) the search amount was reduced to 1384 EA articles and 1600 NG articles.

After removing the duplicates, the results were uploaded into Rayyan (Johnson & Phillips, 2018) and appointed to two senior researchers in the field of Business and Information Management. Based on the criteria mentioned in section 3, all titles, abstracts and keywords of the articles have been scanned for relevance to this research. For the EA articles this resulted in 99 articles included and 90 articles on which the researchers initially disagreed. For the NG articles 64 articles were included and 179 articles where a conflict. The conflicting articles were discussed by the researchers, resulting in a total of 149 EA articles and 141 NG articles included.

During the search for full paper versions of the articles 129 EA articles and 127 NG articles were found and translated into Gephi compatible files for Graph Edges and Nodes based on the quotes using a python script (Mass & Faler, 2020). The citations of the articles in the largest citation clusters were scanned for possibly relevant missed articles. The citations of the articles in the largest citation clusters were scanned for possibly relevant missed articles. This resulted in the inclusion of 5 additional EA and 4 NG articles. Figure 2 shows the end results. To improve the readability, this result was converted to VosViewer (Levallois, 2021).

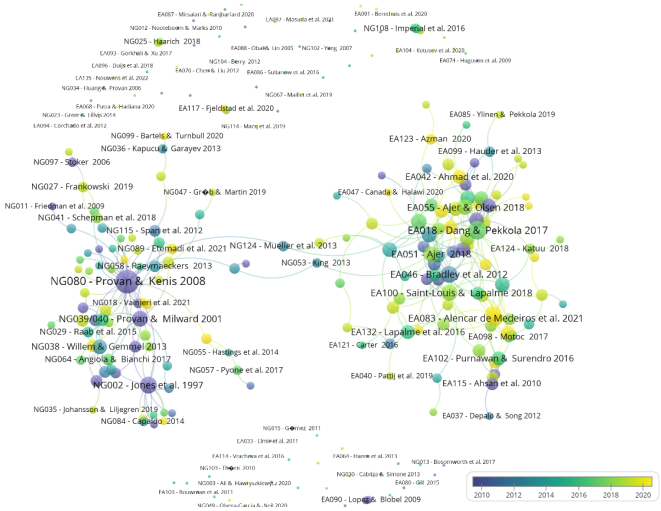


Figure 2: Citation map of EA and NG articles

Figure 2 shows that a citation map can be generated automatically, which helps to select the most relevant articles for the full paper phase of the SLR.

5 Future development

The findings of the first sub-study are expected to provide a list of EA elements associated with the characteristics of NG. On the basis of the first selection of articles, the following picture can be carefully drawn:

1. EA frameworks were originally intended to map the as-is and to-be coherence (eg Zachmann, BPMN and Archimate). Then there were frameworks that also support the process (e.g. TOGAF and DyA) and nowadays we also see frameworks exist and are further developed that deal with managing EA (e.g. SAFe, Sensemaking and Situational architecture).
2. In general, EA assumes that 'the basics' can and must be put in order. As long as the basics are not in order, people are unable to respond flexibly to organizational issues. Unfortunately, it is unclear what exactly is meant by 'the base'.
3. NG can be classified into gradations based on hierarchical relationships between network parties. For example, a supply chain has a different management structure than a crisis organization. In addition, the parties involved will have different EA maturity levels. This means that mapping

the as-is and to-be coherence (in terms of model, process and organization) within a network is situational.

My own vision is that in networks 'the basis' is a digital twin of the network. In other words, the data of the organizational network. I am curious whether this image is recognized and whether data in the case of NG can act as a starting point in addition to or even instead of determining the common goal.

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DOCTORAL CONSORTIUM

FOSTERING COLLABORATIVE DIGITAL TRANSFORMATION IN INDONESIAN LOCAL GOVERNMENT

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Abstract The purpose of this article intended to contribute as a additional reference in the field of public administration and to overlook a concept for the development of digital government transformation that focus on collabrations. This article uses a systematic literature review to explore how collaboration can play an important role in the implementation of digital transformation in local government. West Java Digital Service (JDS) is a digital-based local government agency in West Java Province, Indonesia has a goal as an accelerator of achieving government targets to break the digital divide for remote communities, improve the efficiency and accuracy of community data policies based on data and technology, to support responsive, adaptive, and innovative policy. Initial findings show that JDS does not originate from the purity of the bureaucracy, but rather an institution that formed specifically according to the needs in the acceleration of digital transformation. This means that not all local governments in Indonesia have these digital-based institutions. This article provides an overview of how Indonesian local government deliver a digital-base policy through joint decisions making, that seek to share power in decision making with stakeholders to develop shared recommendations for lasting solutions to public problems.

Keywords: digital government, collaborative governance, pentahelix, local government, public policies.

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1 Introduction

Digital transformation in the public sector means new ways of collaborating with stakeholders, building new frameworks of service delivery, and creating new forms of relationships(Misuraca et al., 2020). A successful digital transformation will enable public sectors to operate efficiently and effectively in the digital environment, and to deliver public services that are simpler and more effective policies (Greenway et al., 2021). However, fully realising this digital transformation requires a paradigm shift from e-government to digital government (OECD, 2014). Digital government approaches favour the use of ICTs for improved collaboration with stakeholders at different stages of the policy and service lifecycle, based on Government as a platform and user-driven policy environment for efficiency improvement and customized service development based on shared ownership and shared responsibility with civil society (OECD, 2020). Moreover, bringing citizens actively on board through collaboration in the design and implementation of policies and services further increases their legitimacy and effectiveness, and creates a feeling of ownership to their government.

The rapid development, deployment, and proliferation of the new and emerging ICTs through digital government create new opportunities for growth and development in countries around the world, including Indonesia. Government fungtions in Indonesia are classified into absolute and concurrent tasks. It is only the central government that manages absolute tasks, which include foreign policy, defence, security, the monetary system, the judiciary, and religion. The local government, including provincial and district governments, concurrently manage the other tasks, which include public works, health, education, culture, agriculture, communication, industry, trade, investment, environment, land, cooperation, and labour. In the overall distribution of tasks, the role of local government is to conduct the most needed public policy, providing services delivery, which usually includes education, health, and basic physical infrastructure, including ICTs. In addition, there is a principle of "money follows function", which means that the transfer of tasks to local governments is then followed by a transfer of financial resources needed to execute them(Sutiyo & Maharjan, 2017).

Governments are seeking to harness the potential offered by these modern technologies to create new dimensions of economic and social progress. In recent years, governments around the world, including Indonesia, have tried to take advantage of information and communication technology (ICTs) to improve the quality of government administration and the quality of communication with citizens. Digital Government is not only about modernising public administration through ICTs, but it is a key enabler in the building of citizen-oriented, cooperative, and modern governance.

For local government in Indonesia, the concept of digital government transformation emerges as a strategy to address problems associated with its population and teritory. In this article, the author will focus on one of the biggest local governments in Indonesia, West Java Province. With a population of more than 49 million people, equivalent to 20 percent of the total population of Indonesia. The expanse of area with an area of 3.7 million hectares is also one of the largest in Indonesia, West Java Province consists of 18 regencies, 9 cities, 5,312 villages, and 645 sub-districts. (Pemprov Jabar, 2022)

As one of the largest provinces in Indonesia, West Java experiences the most rapid population growth for ages. In line with high quality of human resources that have encouraged the social-economic development, made West Java one of the most productive and economically competitive province in the world. But like other big local government in Indonesia, West Java have had to deal with many recent problems in this digital era. This has presented local governments with challenges on delivering public policies and public services like education, public transport, and health services with equal access for everyone.

To accelerate digital transformation in West Java, Governor of West Java, Ridwan Kamil established Jabar Digital Service (JDS) as a government institution based on information technology innovation to assist efficiency in governance, policy making, accountability, community participation and the development of innovative and responsive public services. Jabar Digital Service (JDS), or the Center for Digital, Data, and Geospatial Information Services for West Java Province, aspires to realize the vision of the West Java Government as a digital province that is based on data and technology, supports community services and responsive, adaptive, and innovative policy making.(Jabar Digital Service, 2021)

This unit is under the coordination of the West Java Province Communication and Information Office, JDS has a mission to realize data-based policy making, accelerate government digital transformation, and simplify people's lives with digital technology. As one of the agencies that assist the West Java provincial government in developing the province of West Java based on data, aspirations or complaints which are a form of feedback, it can be used to help improve the quality of public services or improve public service infrastructure. One of the visions of Governor Ridwan Kamil in his government is to make West Java a digital province. JDS as a form of solution to overcome the problem of the digital divide between villages and cities, increasing efficiency and accuracy of policy making based on data and technology for the realization of West Java as a digital province based on data and technology, in supporting services and decision making. responsive, adaptive, and innovative public policies.

1.1 Collaboration to pave the way for Digital Transformation

The collaborative process according to Ansell & Gash is a series of components that run to form a cycle, influence each other, and in essence is a collactive decision-making process (Ansell & Gash, 2008) Including the following:

1. Interface dialogue (face-to-face dialogue). Communication is crucial in the collaboration process, because of the orientation of consensus formation. Communication is often formed through direct discussions (face to face). Open communication then affects the formation of trust between actors.
2. Build trust (trust building). Activities that are continuously carried out and need to be improved. Building trust is a condition for building solid collaboration. Building trust is a time-consuming process and requires a long-term commitment to achieve collaborative outcomes.
3. Commitment to the collaboration process (commitment to the process). Commitment is an important component as well as a major challenge in the collaboration process. Commitment is influenced by the previous component (build trust). Meanwhile, the influencing factors (in terms of components) are mutual recognition and joint appreciation between actors. In addition, the ownership of the process (a sense of ownership of the process) which is manifested by the influence of each actor in making decisions is a driving force for commitment, but has a dilemma, due to differences and complexity in collaboration.
4. Shared understanding. In another sense, they are common mission (general mission), common purpose (general purpose), common objectives (general

objectivity), and shared vision (shared vision). The existence of a common understanding is a necessary condition during the collaboration process, so that common goals can be realized. The understanding in question is the unification of goals, defining the problem together, so as to minimize the occurrence of mutual misunderstanding or misunderstanding.

5. Temporary impacts (intermediate ourcomes). The impact in question is that which occurs during the collaboration process, so there is the word "temporary" in it. This temporary impact generates feedback. More positive impacts are expected, as a booster and guard to keep collaboration on track, so they are called "small wins" or small wins.

1.2 Collaborative Outcomes

The definition of outcomes according to Emerson et all (Emerson & Nabatchi, 2015) is "the third-order effect of the result on the ground", or the third form of development of the effects produced by collaboration in the field. Outcomes have the characteristics (1) there are desired outcomes, and (2) undesirable outcomes. This definition explains that outcomes occur from the continued development of effects, which have the characteristics of (1) having a desired outcome, and (2) an undesirable one. The two outcomes refer to positive and negative things. Impacts can be physical, environmental, social, economic, and/or political. The resulting impacts include added values resulting from collaboration so as to form a better society, or technological innovation, as stated by Emerson et all (Emerson & Nabatchi, 2015) namely: "…may also include the added value of a new social good or technological innovation developed by collaborative action".

1.3 The Pentahelix collaboration as an integrative approach to accelerating digital transformation

To accelerate this digital transformation, the West Java Government has taken a collaborative approach with the pentahelix concept. The pentahelix collaboration is a form of collaboration that involves five development actors, namely academia, business (private sector), community, government (public sector), and Non-Government Organizations or media (Viken, 2021). Based on the experience of the West Java Provincial Government, several criteria that need to be considered in selecting actors to join the task force in the pentahelix are: a) actors who are able and willing to participate in the entire planning process, from plan preparation to implementation of actions; b) actors who contribute constructively to the process;

c) actors who have networks in related sectors; and d) actors who can represent a larger variety of stakeholders than pentahelix. Therefore, in principle, not all parties within the government circle can join the pentahelix team. Interpreting this concept, there is actors who play a role in the development of digital gtransformation in West Java knows as ABCGM (academician-business-community-government-Media). In this case recommends the types of actors who are very suitable to be included in the pentahelix.



Figure 1: A collaborative approach to academics, business, community, government, and media

Source : (Jabar Digital Service, 2021)

The types are as described below (Viken, 2021):

1. Government actors (public sector) should meet the criteria: (a) are administrative representatives of cities, local governments, national government agencies, and (b) are political representatives of city governments or local governments (chosen to represent local or regional authorities in the task force).
2. The private sector (business) should meet the following criteria: (a) representatives from trade unions, trade unions or similar organizations; (b) representatives of the cooperative structure.

3. Non-governmental organizations should meet the following criteria: (a) local or regional environmental organizations; (b) national environmental umbrella organization; (c) the trade union governing natural scientists (may have knowledgeable and relevant representatives); (d) if any, youth environmental organizations.
4. The community should meet the following criteria: (a) resident associations; (b) trade unions and other organizations covering many and diverse citizens. These could be umbrella unions, and/or trade unions focused on influential industries; (c) interreligious organizations.
5. The academician meets the following criteria: (a) is an academic or administrative employee at a local or regional university or college; (b) is a researcher from a local research center.

1.4 Digital Government

The digital transformation shifts from e-government towards digital government (Vlahović & Vracic, 2015) require the introduction of the initiatives needed to make deeper changes in the provision of online services through government portals, into a broader government business. New, 'transformed' technology-based systems must not only be consumer-friendly, strategy driven, and capable of providing a better experience for those who interact with government, but more importantly, must also improve the way government operates (Barcevičius et al., 2019). Additionally, the shift shall allow governments to simultaneously satisfy the needs of the public sector itself; address the challenges of public sector employees and policy makers; and benefit all citizens. Janowski et al., (Janowski et al., 2018) view this shift as empowering citizens and other stakeholders to contribute to or lead the creation of public value, often recognised as one key feature of digital government transformation. Therefore, digital transformation towards digital government potentially transforms citizen-to-government interactions in two ways: by improving policy and service delivery, and by improving relations between citizens and government (Fountain, 2004). The government as a policy maker carries out thinking ahead, thinking again, and thinking across in detail, coherently, and consistently (Rahmatunnisa, 2019)

Based on the explanations above, the emergence of information and communication technology (ICT) in the field of public administration has been understood as a central part of the process of modernizing public administration. In a broader sense, the concept of digital transformation, digital government and e-government has

been used as an administrative reform strategy in the last two decades. This concept also resulted in an increase in the volume of research literature in the field of public administration and ICT, which has created multi-disciplinary knowledge and interesting research analysis and is relevant for the future development of public administration.

This article will thoroughly look at the steps to accelerate digital transformation carried out by the West Java Provincial Government, especially the pentahelix collaborative approach and the factors that influence the process. It is important to note that, although it is not possible to separate government processes from the technologies used in those processes, technology still occupies a limited place in the theoretical understanding of the public sector. The outcome of this article intends to contribute as a new reference for academics in the field of public administration and government studies and promote a model for the development of digital government transformation focusing on collaborative process in public policies.

2 Method

This article uses case study methodology to understand why and how a social phenomenon of interest occurs through data. Case study methodology is an appropriate approach to conducting this exploratory research (Yin, 2017). This study is also inductive so that it contributes to building new understanding. Case studies in local government are rare, and often tend to cover only certain practical issues in public policy and administration. Such practical matters could address a range of issues: from dealing with problems associated with reforming and restructuring ICT management in a local government setting (Nam & Pardo, 2011). This paper expands that research by exploring the ways in which collaborative governance affects digital government transformation in the Indonesian government. This research was conducted using a literature review research design. This research design was chosen because it is very effective in capturing empirical data from various secondary sources (Snyder, 2019). The collected data was then analyzed qualitatively following the steps of data analysis according to Miles et al.(Miles & Huberman, 1994), which includes condensation data, display data, and conclusion drawing/verification. In order to ensure the validity of the data, triangulation of sources was carried out during the research. Thus, the validity/validity of the data in this study was checked by matching three or more sources (triangulation). This stage

is necessary so that the data obtained is truly valid in accordance with the actual conditions. Besides being clarificative, this step is used because it can reduce unnecessary data (Woodside, 2010). There are at least four basic forms of triangulation proposed by Denzin (Denzin, 2015), but this study only uses one of them, namely data triangulation (informants/sources). Data that is considered valid is data that has similarities or similarities (mutually reinforcing) between one source and other sources.

3 Result and Discussion

3.1 The objective condition of digital transformation in Indonesia in general

Indonesia has experienced significant economic growth in recent years and is transforming from an upper-middle-income developing country to one with an inclusive, modern, and respected economy on the international stage. One of the growth factors is rapid industrialisation, which can encourage national economic growth. Indonesia's real Gross Domestic Product (GDP) has more than doubled from USD 0.5 trillion in 2009 to USD 1.1 trillion in 2019. However, this condition is not in line with the level of innovation development that accompanies GDP growth. It can be seen on the 2019 Global innovation index (GII) that Indonesia's GII value is below Brunei Darussalam, the Philippines, Thailand, Vietnam, Malaysia, and Singapore. Indonesia's ranking in 2019 was 85, or the second lowest position compared to other countries in ASEAN (katadata.co.id, 2019)

Recognising the enormous benefits of digital transformation, President Joko Widodo, at the Limited Meeting on Planning for Digital Transformation, delivered five directives focusing on accelerating the national digital transformation agenda through five steps, namely: accelerating the development of digital infrastructure and the provision of internet services, preparing a digital transformation roadmap in strategic sectors, accelerating the integration of national data centres, developing human resources and digital talents, and preparing various regulations and financing schemes to support the digital ecosystem (Setkab, 2020). The five steps to accelerate digital transformation launched by President Joko Widodo are the foundation for the development of the Digital Indonesia roadmap. Digital Indonesia has set six strategic directives to realise its vision. The six directives aim to direct Indonesia

towards an innovation-based economy with world-class technological capabilities, skilled Human Resources (HR), and a society with a digital culture that is ready to face the future. In addition, the 2021 Draft State Revenue and Expenditure Budget (RAPBN) mandates some spending focuses to realise digital transformation in Indonesia. The Indonesian government has budgeted IDR 30.5 trillion in 2021 for ICT development, which is focused on several aspects (Setkab, 2020):

1. Acceleration of digital transformation for the administration of central and local government.
2. Realising efficient and fast public services, especially in the fields of education, health, and government.
3. Consolidation and optimisation of infrastructure, especially those used with cross-sectoral institutions.
4. Realising community inclusion in developing priority areas and promoting equality with additional internet access in 4000 villages and sub-districts.

Digital infrastructure, the acceleration of digital transformation, and increasing human resource productivity through economic knowledge, are the focus of government spending in 2021. The development of digital infrastructure such as the internet is indeed needed, considering that there is still inequality in internet access in Indonesia. The average percentage of households with internet access in urban and rural homes in West Java Province reached 31.65%, while in Papua Province it was only 10.06%, East Nusa Tenggara Province 13.73% and Maluku Province 20.26%. Inclusive internet access is a necessity to realise digital transformation, but it is not the only determining factor. Other key factors include research and development (R&D) capabilities, production innovation capabilities, and talent capabilities. Unfortunately, Indonesia's capabilities in these various indicators have not shown encouraging results.(katadata.co.id, 2019)

Indonesia has maintained steady growth in internet connectivity, mainly driven by rapid investment in network infrastructure by the private sector. The share of the adult population connected to the internet has almost quadrupled, from 13 percent in 2011 to 51 percent in 2019. Despite this impressive growth, 49 percent of Indonesian adults are still not connected to the internet and a significant digital divide remains. across various spatial, economic and social dimensions. For example, the urban-rural connectivity gap is large and appears to have increased over the years.

In 2019, 62 percent of Indonesian adults in urban areas were connected compared to only 36 percent in rural areas. Urban and rural internet connectivity was 20 and 6 percent, respectively, in 2011.

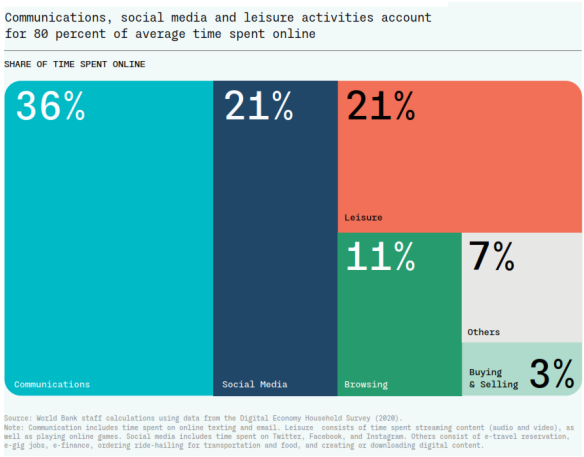


Figure 2: The share of time spent online in Indonesia
Source : Beyond Unicorns Report, the World Bank (World Bank, 2021)

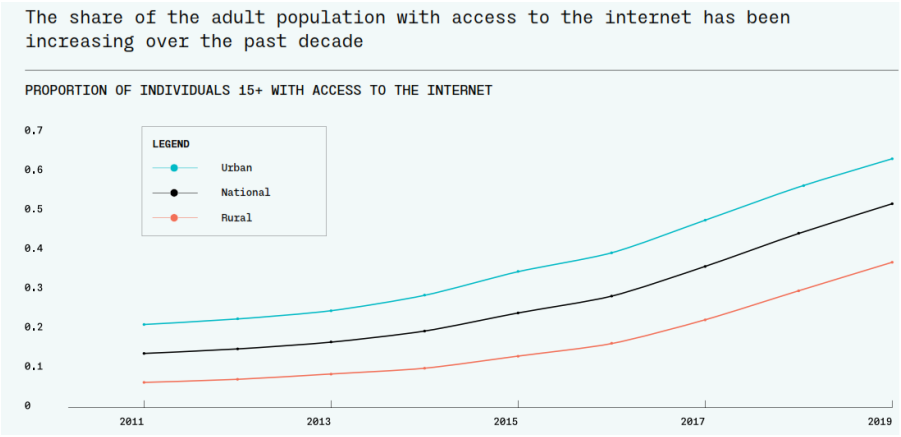


Figure 3: Proportion of Individuals with access to the Internet
Source : Beyond Unicorns Report, the World Bank (World Bank, 2021)

Likewise, there are also sharp generation, education and gender gaps. Younger adults were significantly more likely to connect, as were better educated adults. Men are 8 percentage points more likely to be connected than women, indicating possible inequality in household device ownership. On the other hand, the number of internet users in Indonesia released by We Are Social has touched 175.4 million users. There was an increase of 17% and if calculated, the number of internet users was 25 million, an increase compared to 2019 (World Bank, 2021) The Ministry of Communication and Information Technology of the Republic of Indonesia in 2017 conducted a survey and obtained the results that 66.3% of Indonesians own a smartphone (Indonesiabaik.id, 2018). The increasing need for gadgets every year gives a positive signal for public service innovation.

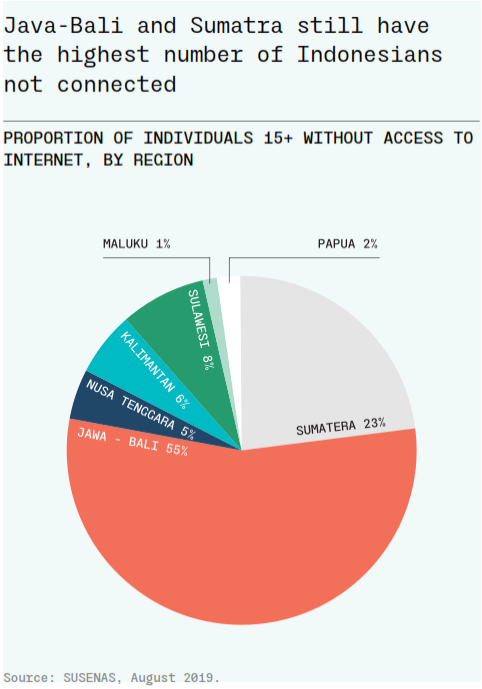


Figure 4: Proportion of Individuals without access to the internet by region
Source : Beyond Unicorns Report, the World Bank (World Bank, 2021)

Indonesia itself has great potential in utilising and developing digitalisation opportunities. As stated in the National Medium Term Development Plan (RPJMN) 2020-2024, the assumption of the digital economy's contribution in 2020 is 3.17%,

and in 2024 it is forecast to be 4.66%. GDP growth for information and telecommunications in 2020 is predicted to be 7.12%-7.54%, while in 2024 GDP growth will be 7.54%-8.78%. In addition, the contribution of the Indonesian Ministry of Communications and Information Technology's digital program to Non-Tax State Revenue (PNBP) continues to increase. As of the end of 2020, Kemkominfo's PNBP reached Rp106.1 trillion. In the 2015-2019 period, Kemkominfo's PNBP grew an average of 3 percent per year. The government itself has allocated infrastructure funds both through the APBN and PPPs to build a strong and inclusive digital infrastructure.

However, Indonesia is considered not ready to take full advantage of this potential. In the Network Readiness Index (2020), which measures readiness to innovate in the face of the digital revolution, Indonesia is still ranked 73 out of 139 countries. Meanwhile, according to data from the World Digital Competitiveness Ranking (2020), digital transformation in Indonesia is far from countries in ASEAN. Indonesia is ranked 56th out of 63 countries, while Thailand is in 40th position, Malaysia is in 26th position, and Singapore is in second position. According to the World Economic Forum (2015), a 10% increase in internet access correlates with a 1.2% increase in economic growth in developing countries. Meanwhile, the addition of cellular subscribers up to 10% will increase GDP by 0.4%.

The Indonesian government has made great efforts to close the digital divide, especially with the implementation of the Palapa Ring project, which aims to expand the country's fiber optic backbone infrastructure to the eastern outer islands. With the completion of the Palapa Ring project in 2019, all 514 cities/regencies in Indonesia are now connected to the national backbone. This has led to a tremendous increase in the proportion of adults connected to the internet in all areas of the country's main island. But there are still sizeable gaps across the region. For example, Based on the Beyond Unicorns Report, the World Bank only about a third of the adult population in Papua is connected, compared to about 55 percent in Java-Bali. At the same time, the fact that almost half of the population, even in areas with relatively better infrastructure, remain without internet access points poses a major challenge in the middle and last mile connectivity segments. The income gap in access is also very large. Adults in families (World Bank, 2021) internet than adults in the poorest decile, only 14 percent of whom are connected. This sharp income gradient suggests possible affordability constraints in access to the internet.

However, In the latest developments, there are several positive points that can be turning points in digital transformation in Indonesia. It can be seen from the collaboration at the level of policy making, fiscal support and infrastructure. The provision of an electronic-based government system in Indonesia (SPBE) involves cross-sectoral government agencies; the Ministry of State Apparatus and Bureaucratic Reform, the Ministry of Communication and Information, the Ministry of National Planning, the Ministry of Finance, the Ministry of Home Affairs, the Agency for the Assessment and Application of Technology (BPPT), and the National Cyber and Crypto Agency (BSSN). Collaboration in governance has the implication that all parties involved have the same responsibility for decisions taken, therefore collaboration requires that the parties involved must sit at the same table and have the same power in decision making (Maulana, 2020).

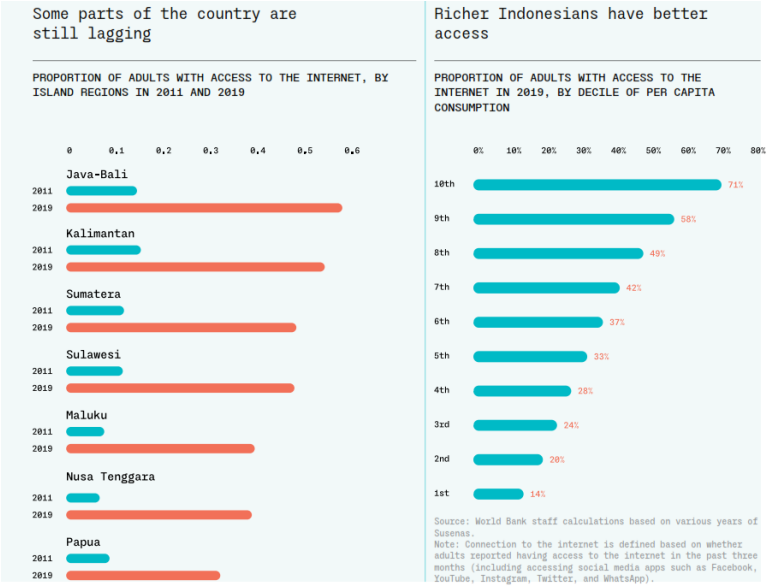


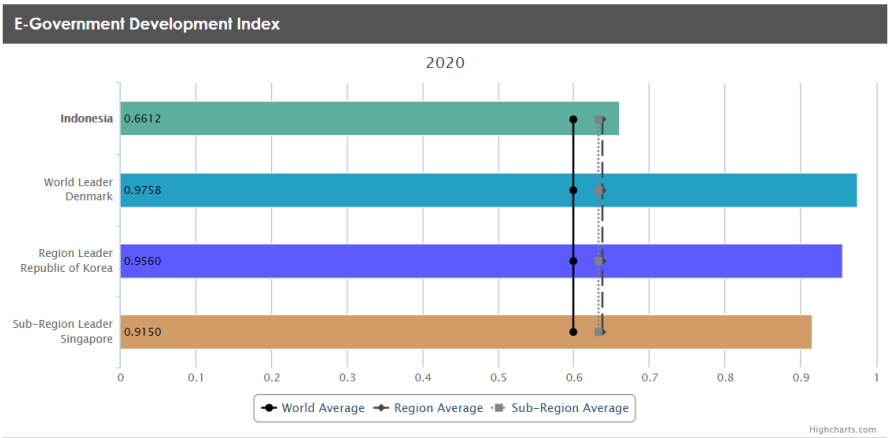
Figure 5: Proportion of adults with access to the internet by island and decile per capita consumption

Source : Beyond Unicorns Report, the World Bank (World Bank, 2021)

The United Nations (UN) e-Government Survey 2020, with the theme Digital Government in the Decade of Action for Sustainable Development, predicts countries that get more than 0.75 points as very high EGDI, 0.50 to 0.75 as High EGDI, 0.25 to 0.75 points. 0.50 as middle rank EGDI, and less than 0.25 as Low

EGDI. In this survey, Indonesia is ranked 88th in the development and implementation of e-government or an electronic-based government system (SPBE). Indonesia received an increase of 19 ranks compared to 2018, which was at 107th, and 116th in 2016. (UN, 2020). Overall, Indonesia got a score of 0.6612 in the High e-Government Development Index (EGDI) group in the UN e-Government Survey 2020, a result which put Indonesia back in the top 100 world rankings at position 88 out of 193 countries.

The challenge of digital transformation in Indonesia today is uneven infrastructure, as the condition of Indonesia's ICT infrastructure is still not evenly distributed throughout Indonesia. This is shown by the fact that there are still 12,548 villages/sub-districts that have not been reached by 4G services, 9,113 villages/sub-districts in the 3T (Underdeveloped, Frontier and Outermost) areas, and 3,435 villages/sub-districts in non-3T areas. Internet access in Indonesia is also still quite low. Based on Speedtest Global Index 2020 data, Indonesia's internet access speed is ranked 120th in the world, while for fixed broadband speed, Indonesia is ranked 115th in the world.(indonesia.go.id, 2022).



E-Government Development Index	2020	2018	2016	2014	2012	2010	2008	2005	2004	2003
Indonesia (Rank)	88	107	116	106	97	109	106	96	85	70
Indonesia (Value)	0.66120	0.52580	0.44784	0.44874	0.49486	0.40264	0.41070	0.38186	0.39090	0.42243

Figure 6: Comparation between Indonesia e-government index and the other leading country in regional and global perspective
Source: UN e-Government Survey 2020 (UN, 2020)

From the explanation above, it can be said that various efforts and initiatives have been carried out by the Indonesian government since the issuance of Presidential Regulation No. 95/2018 on e-Government for optimising digital government in Indonesia, but they are still not optimal and even far from what is expected by the regulations, although it is undeniable that there are several regions that show good performance in developing digital government. Based on some of the existing literature, there are many factors that can hinder and challenge the implementation of digital government in Indonesia (Alryalat et al., 2017; Maulana, 2020; Schwertner, 2017)as follows:

1. There is no clear standardisation regarding the implementation of digital government and the lack of socialisation on how to implement ICTs in a real and ideal way for collaborations in local government, which is related to the sustainability of the policy innovations.
2. The unavailability of adequate human resources to manage the business processes of digital government, which causes a gap between the government's internal bureaucracy.
3. The infrastructure network for technology and information is not evenly distributed to the regions (local government).
4. Lack of community engagement and digital literacy related to the use of ICT's because the majority of the population is in the lower and middle-class group.
5. Lack of commitment from top level policy makers in local government to support digital government implementations, which has hampered collaboration with stakeholders, including citizens.
6. Organisational culture that is less supportive of change, and a low culture of sharing knowledge and information, especially between government agencies.

3.2 Pentahelix's Collaborative Approach in West Java Province

Through the concept of digital government, West Java Provincial Government intends to make the government come to the people - not the other way around. This option is realized by cooperating with the provincial government on third parties so that the public can get public services online (jabarprov.go.id, 2019a). The acceleration of digital transformation in West Java is in line with the regional medium-term development plan (RPJMD) for 2019-2023. The elaboration of the vision and mission on the RPJMD is carried out through innovation and collaboration, The West Java Province Vision Statement 2018-2023 with the

terminology "Innovation" means that development carried out in various sectors and regions is supported by innovation aimed at improving public services, quality of life and sustainable development. "Collaboration" means that the realization of the vision is carried out by collaboration between levels of government, between regions and between development actors to take advantage of potentials and opportunities and to answer development problems and challenges.

The RPJMD document introduces a new approach to development in West Java, one of which is the Pentahelix collaborative approach, represent collaboration with development stakeholders better known as ABCGM (Academic, Business, Community, Government, and Media). The implementation of development is expected not only to be limited to the process or method that has been carried out so far, but also to be accompanied by various forms of reform in the administration of regional government. Likewise, it is hoped that intensive collaboration will be established between the West Java Provincial Government and the central government as well as with district/city local governments, the private sector, NGOs, the media, and the public in general. Therefore, of significant steps are needed to harmonise the digital government with the collaboration process, strategies in public engagement, the provision of policy and public delivery. According to Denis Anderson, et al (Anderson et al., 2015), the government's effort to be able to provide public services in a way that is fair, effective, inclusively centered on citizens, and a public sector that has the capacity to provide services, needs to be strengthened at the central and regional levels. This means that effort is needed to strengthen the four main dimensions in the public sectors: (1) public institutions - especially at the regional level, to provide services; (2) leadership capacity and human resources - needed to provide services in a transparent, fair, efficient and accountable manner; (3) processes and mechanisms - that support citizen participation in service design and delivery; and (4) organisational culture - so as to create space for continuous improvement and innovation in service delivery to the community.

The achievement of indicators in the fifth mission in the West Java PRJMD related to collaboration is shown by 2 (two) regional performance indicators, namely the bureaucratic reform index and the level of effectiveness of regional cooperation. The achievement of the bureaucratic reform index was recorded in the BB category in 2019. This index can be interpreted that the results of the evaluation of the Ministry

of Administrative Reform and Bureaucratic Reform of the Republic of Indonesia represent significant results on bureaucratic reform in the Regional Government of West Java Province. As for the achievement of the effectiveness of regional cooperation, it was recorded at 71.33 percent of the target of 54 percent. This condition can be interpreted that the cooperation agreement which is followed up until the results of the cooperation can be realized and shows a positive improvement. As a result, according to the 2018 maladministration perception survey, West Java Province was ranked second after NTT in terms of the quality of public services. This is much better than North Sumatra, Jakarta, Jambi, and the other five provinces surveyed. The West Java Provincial Government, in this case, is able to run a 3.0 government based on community dynamics and technological developments. This model is much more advanced than the performance-based government model and the rule-based government model. (jabarprov.go.id, 2019a).

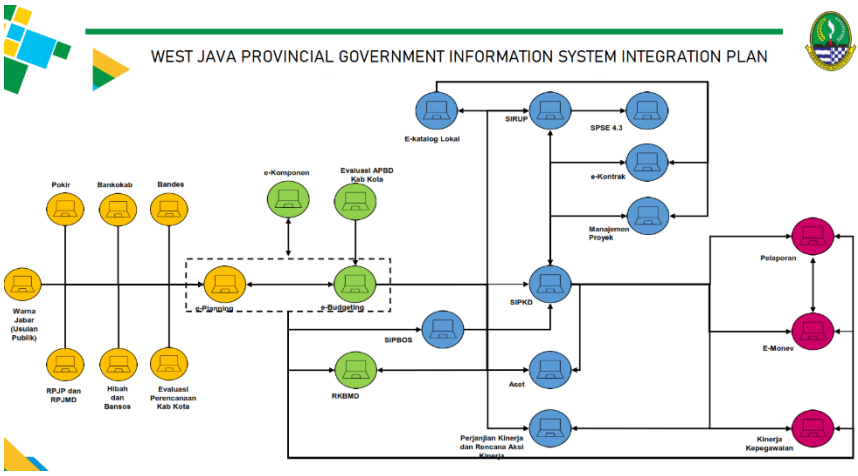


Figure 7: West Java Provincial Government IS Integration Plan
Source : West Java Provincial Government IS Integration Plan (jabarprov.go.id, 2019b)

From the explanation above, collaborative efforts have been institutionalized into the development planning system, especially maximizing the role of multi-stakeholders in helping the government achieve its goals. From the government aspect, of course, the acceleration of digital transformation efforts in this government cannot be separated from the desire to create an organization that is able to manage collaboration, in line with one of the goals of the Governor of West Java, Ridwan Kamil in his administration, is to realize West Java as a Digital

Province. This concern stems from the high disparity between rural and urban areas in technology. The lack of supporting infrastructure in rural areas makes it difficult for villagers to enjoy the benefits offered by digital technology. This is what gave birth to the idea of forming the West Java Digital Service (JDS) or Regional Technical Implementation Unit for the Center for Digital, Data and Geospatial Information — a unit under the West Java Province Communication and Information Office which is aspired to be able to narrow the digital divide, help efficiency and accuracy. decision making based on data and technology, as well as revolutionizing the use of technology in people's lives and government in West Java.

JDS's vision is to create a data and technology-based West Java to support responsive, adaptive, and innovative community services and policy making. JDS has 3 visions, namely: 1) Data for Decision Support - System Realizing policy making based on data. 2) Government Digital Transformation -Accelerate the digital transformation of government. 3) Improving Citizens Digital Experience - Easing people's lives with digital technology.



Figure 8: Pentahelix collaboration in West Java Digital Village Program
Source: Pentahelix collaboration in West Java Digital Village Program (Jabar Digital Service, 2021)

This is what the West Java Provincial Government has done with JDS. In order to adapt to community needs while keeping pace with the times, the West Java Provincial Government initiated several innovations, including the application of the Penthahelix concept and the implementation of the Digital Village program (jabarprov.go.id, 2019b). In the context of equitable village development, we

optimize the Digital Village program with the pentahelix approach. In 2021, this program comes with a new thematic in line with the agenda of The 2021 United Nations Climate Change Conference (COP26), namely integrated waste management (waste management) and the production of environmentally friendly (biodegradable) packaging accompanying other initiatives in the fields of agriculture, animal husbandry, fisheries, health and multimedia. It was recorded that 1904 villages became beneficiaries for the Digital Village program.

The implementation of the Digital Village program is an effort by the West Java Provincial Government to improve the residents' economy by maximizing the village's potential through collaboration with various partners. In 2021, Digital Village will continue to pursue the procurement of digital infrastructure to stimulate village economic growth. It was noted that until March 2021, a total of 353 VSATs (Very Small Aperture Terminals) had been installed and replication of digital wi-fi villages had been carried out. Not only that, with digital access, the provision of digital literacy through assistance with partners and the community is also improved. 141 villages have received digital literacy training. A digital literacy webinar with the concept of Training of Trainers was also held to increase digital literacy and awareness of hoax information, through cadre representatives from each region. Utilization of village potential through the digital economy has also been implemented in several village points in West Java.

In collaboration with Tokopedia and Shopee to launch the Village Digital Center (Talesa), now 35 villages have utilized technology to support the potential for economic development of their villages. Of the 24 villages targeted for the expansion of Digital Villages, it turns out that this year we have succeeded in implementing thematic digital villages many times over. This achievement has made village independence through digital innovation implemented in a total of 460 villages in West Java.

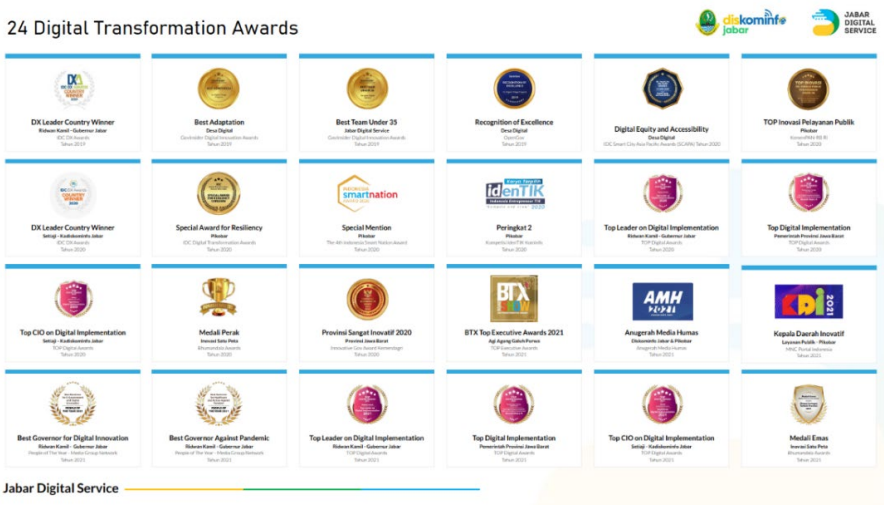


Figure 9: The award received by the West Java Provincial Government in an effort to accelerate digital transformation

Source: The award received by the West Java Provincial Government in an effort to accelerate digital transformation (Jabar Digital Service, 2021)

Cross-sectoral collaboration for community development

Supervision of the implementation of partnership cooperation with Corporate Social Responsibility (CSR) and the Partnership and Community Development Program (PKBL) is currently carried out manually through the Partner Company Contact with the Bappeda of West Java Province considering the West Java Corporate Social Responsibility (CSR) Website which is in the process of being repaired after previously not working because there had been a hack. In the process of improving the Website, innovations such as new features were also added which aim to facilitate data collection and reporting services in the future. One of the special features being designed is the reporting feature on Corporate Social Responsibility (CSR) projects that have been completed. The display of project selection and reporting is presented in several classifications of sectors in accordance with West Java Governor Regulation Number 30 of 2011 concerning Facilitation of the Implementation of Social Responsibility in Corporate Environments in West Java. The sectors referred to include social, environmental, health, education, increasing purchasing power, infrastructure and environmental sanitation, religious facilities and infrastructure and other development programs. It is hoped that the innovations carried out can

support Corporate Social Responsibility (CSR) programs so that they can be more focused and useful in improving the quality of life and a beneficial environment.

Multi-stakeholder collaboration has also been carried out with several collaborations in 2020 relating to ICTs access for community development:

1. Mutual agreement between the Regional Government of West Java Province and PT. Link Net, Tbk Regarding the Provision of Multimedia Services to Improve Public Information Services;
2. Mutual Agreement between the Regional Government of West Java Province and the Infra Digital Nusantara Foundation regarding Cooperation in Revitalizing Vocational High Schools through Corporate Social Responsibility (CSR) Hub.
3. Cooperation Agreement between the Regional Government of West Java Province and PT Link Net, Tbk regarding the Implementation of Channel 50 "West Java Network";

Reorientation of the Promotion Board has been carried out in accordance with the needs of the Millennials market which is filled by the Millennials structure. The use of technology has started, especially for Artificia Intelligent and Big Data has been tested during the West Java Festival 2019 with the concept and design 70% for Millennials in collaboration with Institutions 4.0. One of them is the Smart Tourism System activity with a Budget Realization of IDR 4,570,310,600,000 in 2019 and in 2021 it is proposed to develop a Smart Tourism System of IDR 1,042,126,048.00 improvements to be carried out is to create a Festival Planning Work System. Government support for these activities through an adequate budget.

To solve the problem of the weak mastery and technological literacy of the participants in self-employment training, each self-employment training must include the Digital Marketing Strategy module. This module provides knowledge in terms of mastering basic technology skills including hardware and software introduction, email creation, digital marketplace account creation, marketing using Search Engine Optimization (SEO), and how to market products through online marketplaces. West Java BLKM itself has collaborated with digital online platforms such as Shopee and Gojek (Go Food). The participants received direct material regarding mastery of digital technology in terms of marketing and could directly register as a member who could directly sell on the two platforms. Meanwhile, to

increase service capacity, BLKM needs to improve facilities and infrastructure, especially workshops and training practice tools. Then the limitations of training instructors become an obstacle in terms of increasing the capacity of this training service;

In terms of increasing the number and service capacity of vocational training centers to prepare high school and vocational high school alumni to enter the world of work, the Department of Manpower and Transmigration of West Java Province through the Competency BLK carries out Competency-Based Training activities with various vocational fields including vocational Web Programmers, PNC, Lathe, SWAG Welding and so on. In addition, through the Job Guidance Extension (PBJ) activities, SMK students are prepared to enter the world of work.

The development of this community also reaches a wider audience, JDS formed the Jabar Committee as a forum for the IT community to network with the same goal of making West Java a digital province. This community is a forum for exchanging knowledge and experience, which is the key to this collaboration, one of which is through the implementation of TechUpdate. TechUpdate is a regular talk show held by Jabar Digital Service. JDS invites experts from many communities and organizations to share stories about digital transformation. During the pandemic, the implementation of TechUpdate shifted from face-to-face meetings to virtual meetings. This online event is an effort to adapt so that West Java residents are more familiar with digital technology. Throughout 2020-2021, not a few West Java residents regularly follow TechUpdate, from students to workers, from those who live in cities and villages. TechUpdates are held regularly with various relevant themes in the community to provide technology insight for all. This 1.5-hour webinar series was presented through the media zoom meeting and re-aired through the Jabar Digital Service Youtube channel.

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DOCTORAL CONSORTIUM

CAPABILITIES AND COMPETENCES FOR STRATEGIC DECISION MAKING IN DIGITAL WORLD

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Abstract Technological and digital developments go fast and are interrelated causing the environment of organizations to change rapidly. Furthermore, consumer needs evolve and disruptive business models of new (unexpected) competitors take market share of incumbents. This makes it difficult to determine what the relevant contextual factors are that organizations need to take into account when formulating their strategy. At the same time, the digital possibilities for organizations to add value for their customers, is increasing in an unpredictable way. These substantial uncertainties for organizations, combined with the existential need for organizations to add value in a more effective and efficient way than their competitors, put them at great risk. In this perspective, it is also difficult for organizations to determine what capabilities and competences in the strategic decision unit are required to constitute a good strategy to adopt to digital developments. This paper describes a PhD research project with the objective to find a way for organizations to determine what capabilities and competences in the strategic decission unit are needed to formulate a future-proof strategy in a changing, complex and ambiguous context.

Keywords: digital readiness, digital maturity, digital transformation, digital strategy, organizational strategy, digital capabilities, competences, executive level.

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1 Introduction and some theoretical background

The context of organizations is changing ever faster under influence of a digital transition that is driven by a wide variety of digital technological developments. This transition changes people's behaviour and expectations (Karimi and Walter, 2015) creating new needs and demands among consumers and creating a new social context. Exponents of this society-wide process of change are the use of mobile phones, social media and the implementation of new regulation (Lemon and Verhoef, 2016).

Organizations that are able to adapt faster than their competitors to this digital transition have a competitive advantage as a consequence of the digital transition (Millar et al.; 2018; Karpunina, 2019). Organizations that do not adapt (in time) to new customer desires and social changes run the risk of creating insufficient value for their customers, which can lead to loss of turnover or even bankruptcy (Mazone, 2014; Karpunina, 2020). Therefore, the digital transition should be an important aspect of the organizational strategy.

Because of the digital transition, existing techniques and tools for strategic adaptation are no longer sufficient (Warner and Wäger, 2019; Subramaniam, 2019). Teece et al. (1997) state that this new reality requires organizations to increase their digital readiness and thereby to digitally transform.

In line with these insights scientific prove is found for the relationship between newly developed organizational capabilities and the succes of the organization to digitally transform and to achieve better results. Examples of this are: Fainschmidt et al. (2019) who stated that organiszations should develop a certain degree of environmental sensitivity, especially with regard to digital developments, and Ravesteijn and Ongena (2019) who showed a positive relationship between specific digital transformational leadership competencies within an organization and the extent to which the organization is ready to digitally transform.

A complicating matter when it comes to the timely adaptation of organizations to the digital transformation, is the alignment between business processes and IT processes (BITA). This challenge has been a thorny subject in practice since the start of automation and digitalisation, and is much discussed in literature (Luftman and

Brier, 1999, Bharadwaj et al., 2013, Kahre et al. 2017). One of the complicating reasons for problems with regard to BITA is that the implementation of new digital technologies often affect large parts of organizations, and even go beyond their borders, by impacting products, business processes, sales channels, and supply chains (Matt, et al., 2015). Various models have been developed over the years (Jonathan, 2018) to achieve this alignment.

1.1 Problem statement and research objective

As described above, organizations run strategic risks because of the digital transition, and they must anticipate in time to their unpredictable, complex changing context much faster than before. Traditional techniques and models for developing a strategy are therefore no longer sufficient for every organization in its context. There exist many theoretical and practical models that describe which capabilities are needed to be ready for the implementation of a digital transition (Vial, 2019, Schilke et al., 2018), models and methods that improve organizations digital readiness and maturity or that facilitate the digital transformation of organizations.

But still organizations face a challenge, because the amount of theories and models and the variety in approach, scope and content is so numerous, it is difficult for organizations to determine which theory, model or technique fits best in their situation and their context. Therefore:

The objective of the research proposal presented in this paper is to help organizations by determining which capabilities and which competences in the strategic decision unit they have to develop, to construct a future-proof strategy in a digital transforming world.

1.2 Definitions

Awaiting the results of the structured literature review, this paragraph holds some provisional definitions and discussion of the main concepts used in this research design.

Digital readiness is defined as the degree to which and the speed with which an organization can develop innovative capabilities and apply new technologies, that

better enable the organization to achieve its goals and lead to better results (Walzuch et al., 2007).

Digital transformation refers to the process through which an organization responds to environmental changes by using digital technologies such as mobile computing, artificial intelligence, cloud computing, and the Internet of Things (IoT) to change its value-creation processes." (Vial, 2019)

In this research design the term capability refers to an organizational ability and the term competency is used to refer to an individual ability. In scientific literature this distinction is sometimes made differently.

Competency is the capability of applying or using knowledge, skills, abilities, behaviors, and personal characteristics to successfully perform critical work tasks, specific functions, or operate in a given role or position (Ennis, 2008) *Capability (referring to organizations)* is defined as a capacity of an organization to deploy its resources, tangible or intangible, to perform a task or activity to improve performance (among others Teece et al., 1997).

In the research process the *'future-proofness of strategy'* will be evaluated by the techniques found in scientific literature as done by Punt et al. (2016). For the readability we define future-proofness of strategy in this research design based on the definition of Rich (2014) as the strategy that enables the organization to anticipate to future developments, minimizing the effects of shocks and stresses of future events (robust in multiple scenarios).

The strategic decision unit of the organization consists of those people who make the decision about the strategy of the organization.

1.3 Preliminary Research

To further determine the problem in practice an explorative study was undertaken in which eight experts from strategic development units of organizations participated. The objective of the preliminary research was to determine possible solutions for the outlined challenge of the research project in order to provide direction for continuation and scoping of the following research phases. The

preliminary research consisted of three focus group sessions with the same eight participants of eight different organizations (Morsch, 2021). The main research questions discussed were:

- How do organizations ensure that they are digital ready?
- What risk (chance and impact) do organizations run, not being (fully) digital ready?
- What organizational capabilities and competences will increase their digital readiness (risks)?

There were two reasons this research was spread over three sessions. First, the sessions were intensive and the attention of the participants was limited. Second, the assumption was made that the mutual exchange of insights and ideas would inspire participants and, after returning to their workplace, they would come indepth new insights by reflection. This indeed turned out to be the case and even a fourth session is planned after requests of participants.

1.3.1 Results of the preliminary Research

The analyses of the data collected through the focus groups sessions provided the following results:

- The risk for organizations of a rapidly changing context was recognized and acknowledged. Some participants were able to draw on their own experience;
- Digital transformation without a direct strategic reason was not experienced as useful. A digital transformation process is only wise when the necessity thereof is the outcome of a strategy development process;
- An important cause of slow response to changing circumstances, is the dysfunction of the central strategic decision unit as a result of blind spots.
- Examples of blind spots in the strategic decision unit that are counterproductive when it comes to adaptivity:
    - Too much trust in the old revenue model;
    - The decision making management of the organization is almost always in charge of departments that are responsible for the traditional business model. Innovation could cannabilize on their business units and as a consequence they

might lose influence because of the innovation. This sometimes leads to perverse steering mechanisms;

- Participants stated that an adequate way to increase the digital readiness of an organization is to increase the innovativeness of the organsiation.
- Some suggestions the participants made to increase the innovative capability of an organization were:
    - Delete or solve the blind spots:
    - Reward innitiatives that are innovative;
    - Make innovation power a goal in itself, and make it important to all the coworkers (honour the inventors);
    - Create space for innovations by keeping the innovative initiatives out of the 'normal planning and control' cycle.

The two main findings from this prelimanary study:

- look at the disablers as well as at the enablers when it comes to making a future-proof strategy;
- innovativeness could be a trigger to develop capabilities needed to built a future-proof strategy.

1.4 Gap in scientific literature and research question

In scientific literature, little research is found on the integral process what concrete measures and capabilities will enable the ability in organizations to develop a future-proof strategy (Korachi and Bounabat 2019, Teichert 2019).

Felch et al. (2019) state that little insight is known in scientific literature on the relationship between the process of making a future-proof strategy (and the required capabilities) and the specific context of the organization (Felch et al., 2019, Fainschmidt et al. al., 2019). Even less research analyzes what competences are necessary to fullfill the capabilities needed for digital readiness (Felch et al., 2019, Fainschmidt et al., 2019).

This proposal describes a research project that aims to construct a framework that organizations can use to develop the capabilities and competences in the decision making unit needed for the development of a future-proof strategy. Finally there is very little research in this scientific domains that provides scientific insights from

practice (Warner and Wäger, 2019; Liu, 2017), despite the long standing practical need for the insights studied in this research and the need for some practical evidence of the effectiveness of it.

Based on the above the main question that is formulated for this research project is:

Which capabilities and competences are needed in the strategic decision unit of organizations to help to develop a future-proof strategy in a digitally transforming world?

1.5 Scientific domains

Based on this the following three areas of science are paramount to this research:

- Strategy development: specific theories/methods that are investigated within the strategy determination are external analyses, scenario planning, capabilities (dynamic versus resource based) and competences of the strategic deceision unit of the organization.
- Information science: specific theories/methods that are investigated within information science are digital strategy, digital readiness, digital maturity, digital transformation, and BITA. For all of these the relation to the organizational capabilities and competences in the strategic deceision unit of the organization are studied.
- Human resources management: specific theory/methods that are explored within human resource management are capability management, competency management, blind spots management and in extension of the latter competency frameworks.

In the next section the overall research process is described followed by an in- depth discussion of the first phase in section 3. This paper ends with describing the contribution of this research to both science and practice.

2 Research Process in three phases

This research provides insights into the relationships between organizational capabilities, competences in the strategic decision unit of an organization, the contextual factors and the ability to formulate a future-proof strategy. To match the objective of this research the research question has to be answered:

Which capabilities and competences are needed in the strategic decision unit of organizations to help to develop a future-proof strategy in a digitally transforming world?

Three phases will be distinguished in this research project (besides the earlier mentioned preliminary phase). Phase 1 will provide the building blocks necessary to answer the research question. In phase 2 the building blocks will be put together to answer the research question. In phase 3 the construct will be validated and possible adjusted to make it a better fit with practice.

2.1 Definition phase

Exploring the domains described above from a theoretical as well as from an practical point of view:

- In a structured literature review, insights will also be collected about the relationships between the concepts in the research questions, in order to gain state-of-the-art insights into the integrated research field and the research direction for the follow-up of the research (Okoli, 2015).
- An explorative qualitative research will form a picture of the relationships between the different concepts in the research questions. This is done through semi-strauctured interviews (SSI) among a group of key experts (content experts in the domains of digital readiness and strategy development and practical experts responsible for the strategic direction of the organization). At the start eight interviews are planned with the content experts and sixteen interviews with strategic on the outcomes.

In the first phase of the research project the answers are investigated to following sub-questions:

From a theoretical perspective:

1. *Which capabilities and competences in the strategic decision unit can be derived from theory and methods that are intended to increase the digital readiness and digital maturity of organizations?*
2. *What are the relevant contextual factors in the process of strategy development?*

From a practical perspective:

3. *How do organizations develop their strategy and which capabilities and competences in the strategic decision unit of the organization do they deploy in this process?*
4. *Which contextual factors do organizations include in their process.*

2.2 Theory development phase

Construct a theory, framework or a model which describes the relations between the concepts in the sub-questions of phase one.

Grounded theory methodology matches the objective of the research projects because it is designed to enable the discovery of inductive theory. It "allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data" (Martin and Turner, 1986). In 2017 Wiesche et al. examined studies in the information systems domain based on the grounded theory methodology and they classified the grounded theory methodology research contributions in information systems science as the development of theories, models, and rich descriptions.

The research question(s) and operationalization of the second phase will be determined after the execution of the first phase. This is done because the outcomes of phase one will influence the possible sollutions for the research as a whole and thus will influence the direction of the second phase, while maintaining the research objective.

- Using grounded theory a study will be conducted, aimed at obtaining a deeper insight into the different concepts of phase one. More precise on the basis of the answers to the sub-questions in phase one, the patterns between contextual factors and necessary capabilities and competences in the strategic decision unit of organizations are constructed.

2.3 Validation phase

Definition and validation of the found patterns in phase 2.

- In phase 3, the answers found to the sub-questions are individually and integrally validated in practice with a quantitative survey research. Based on

statistical analysis it is tested whether the developed theory is valid and significant with regard to the relationships between organizational capabilities, competences of the strategic decision unit of an organisation, contextual factors and future-proof strategy. As applies for phase 2, the precise research question(s) and operationalization of this phase depends on the results found earlier.

In the next section the methods used in phase 1 are discussed. The methods for phase 2 and 3 will be based on the results from phase 1 and therefore these methods are not determined yet.

3 Research Methods definition phase

In phase 1 a structured literature review is conducted parallel to a process of semi-structured interviews.

3.1 The structured literature review

The aim of this structured literature review is to answer the first and second sub-questions as defined in section three. For both structured literature reviews, we follow the protocol of Kitchenham (2004) and of Okoli and Schabram (2010). It is a rigorous approach to select, analyze and assess papers. Applied in a given domain, it allows identifying trends and gaps in research. The systematic literature review follows these following 6 steps, which we describe for both questions.

3.2 Digital readiness and digital maturity theory and models

In this SLR the subquestion to answer is:

Which capabilities and competences in the strategic decision unit can be derived from theory and methods that are intended to increase the digital readiness and digital maturity of organizations?

Research identification

The goal is to examine and evaluate research on digital readiness to create an overview of relevant theories and models in order to extract from these the capabilities and competences needed in the strategic decision unit of organizations in regards to digital transformation.

Research strategy

This SLR focuses on models and theories that are related to the terms: digital readiness, digital maturity, digital transformation and digital strategy.
Initially the first goal of the formulated queries is to withdraw other Structured Literature Reviews on the investigated models. The articles selected will provide a definition of the different terms, how to categorize them (purpose, assessment method) and give insights in further search procedures. The results will be used to formulate new queries together with a special focus on capabilities and competences in the strategic decision making unit of organizations.

Study selection

Together with a SLR expert in this domain of science and a short exploratory study, meta search terms for relevant digital readiness and digital maturity articles will be constructed and relevant databanks will be chosen. After the search results are retrieved, the duplicates are deleted. The search results are then assessed for relevance on title, abstract and keywords.

In order to minimize possible bias from researchers, this process is done by at least two researchers. Conflicting articles will be discussed with the aim of reaching consensus.

The inclusion criteria for this assessment are: no foreign language instead of Dutch, English and German, peer-reviewed journal/conference article or dissertation, and the article contributes to the answering of the research question.

The provisional list of databases to be used, are: Academic Search Complete, ACM Digital Library, AIS eLibrary, Elsevier, Google Scholar, IEEE, NARCIS, Science Direct, Springer, Web of Science, XpertHR.

Quality criteria

The planned evaluation in this phase requires the complete review of the paper. Based on the works of Nguyen-Duc et al. (2015) and Hauge et al. (2010) and slightly adjusted from the formulation of Henriette et al. 2015 the next criteria are taken into account: Is there an adequate description of the context in which the research was carried out? Is there a clear statement of research aims? Does the paper describe an explicit research question? Is the research design appropriate to address the research aims? Is the literature review adequate?

Is the collected data addressed to the research issue? Is the data analysis sufficiently rigorous? Is there a clear statement of findings? How is the value qualified? Does the paper discuss limitations or validity?
Each question has four possible ratings: (0) issue is missing, (1) just briefly mentioned, (2) more or less adequately addressed and (3) present and adequately described (Nguyen-Duc et al., 2015). All evaluations with an average outcome lower than 1 will be deleted. All evaluations with an average outcome between 1 and 1,8 will be submitted to a second opinion of an experienced researcher in this domain of science. When the evaluations differ more than 0,4 the paper is discussed. When the average score of the two evaluations together is 1,4 or higher the study is added to the selected papaers for this study.

Data extraction

For the extraction of data the procedures of Kitchenham (2004) will be followed. During the collection of the stored data (besides the trivial data, like name of the review, author, title, objective, date of extraction), the focus in the extraction process will be on all prescribed activities, procedures, capabilities and competences that are mentioned. all primary papers being assessed by at least two researchers. All extraction are done and discussed by at least two researchers. To ensure the extraction is done in a consistent manner, the extraction process is evaluated after the first ten articles with the help of a experienced third researcher. When several

articles are under suspicione of making use of the same study, the researchers will contact the writers of the articles to verify and if necessary combine and handle the insights from the different articles as if it was a single article.

Data synthesis and analysis

In the end, findings are formulated based on the extracted data. The data synthesis includes a descriptive analysis to provide a background about the included articles and an analysis of their findings in order to underline the future directions of research.

3.3 Relevant contextual factors

In this SLR the subquestion to answer is:

What are the relevant contextual factors in the process of strategy development?

For this sub-question a SLR is performed in which the same steps are conducted except for the research identification and the research strategy:

Research identification

The goal is to examine and evaluate research on relevant contextual factors in the process of strategy development.

Research strategy

This SLR focuses on different models and frameworks designed for the contextual analysis of organizations in the strategic development process. Especially those models and frameworks that focuses on the contextual analysis in the digital transforming world (queries involve keywords such as Industry 4.0, VUCA world etc.).

Initially the first goal of the formulated queries is to find other Structured Literature Reviews on the investigated models. The articles selected will provide a definition of

the different terms, how to categorize them (purpose, assessment method, etc.) and give a good view on further search procedures.

The found insights about characteristics in the selected articles will be used to formulate new queries.

3.4 Semi-structured interviews

The strategic development process can be described from many different perspectives and (Mintzberg 1998). Questions like: How is the process initiated? Who is involved? What information is gathered? How is the analysis done? How are decisions made? How to adress and debate differences in opinions?

This part of the research project will start with a brief literature review on the strategic development process to collect relevant angles for questions. Allthough these questions give a good impression on the major themes and how to adress the subjects to the participants, the diverity and complexity of the strategic development process makes it desirable to ask in-depth questions and clarification (Adams, 2015). The process of the semi-structured interviews the steps of Schmidt (2004) are executed. The participants are approached through different networks like, linked in, Dutch Network of Board members (NCD) and Researchgate (expert group).

Each interview is done by an experienced interviewer who has over ten years experience as a strategic consultant and is researcher. The analysis is done by two researchers, discuss the content and to evaluate and adjust the questions posponed.

After the process of transcription the following steps are taken as described by Schmidt (2015):

1. Material-oriented formation of analytical categories on the basis of the full and complete interview.
2. Assembly of the analytical categories into a guide for coding. The first draft of the categories is evaluated with two other researchers.
3. Coding of the material on the basis of the coding guide of each individual interview.
4. Quantifying surveys of material in clear presentation of results in tables.

5. Detailed case interpretations to arrive at new theoretical considerations and to draw conclusions.

4 Rationale/ Contribution / Value

4.1 Practical contribution

This research contributes to reducing the risks for organizations undertaking a digital transformation by creating guidance for organizations when it comes to the necessary capabilities and competences in the strategic decision unit of organizations. Outcomes of this study will lead to advice in regards to which capabilitites (context depended) need to be implemented and correspondingly which competences need to be developed.

4.2 Scientific contribution

The number of theories and methods that science offers to prepare the organization for strategic choices that are future-proof in a digitally transforming world are numerous across the domains of strategy, information sciences, and HRM. There multiple studies that performed a structured literature review within one of these domains determining the different theories, methods and models available. However, there is currently no research known that looks for similarities across all these domains and corresponding theories and methods.

Furthermore, a specific focus on the capabilities and competences that are required in the strategic decision unit of organizations and are needed for strategy development, is ommitted.

4.3 Conclusion

The ultimate goal of this research is to contribute to an practical and easy-to- execute analysis process with which organizations can analyse their internal organization and their context with which they gain insight into the capabilities and competences they need to set up to develop a future-proof strategy.

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DOCTORAL CONSORTIUM

A Rubric to Guide the Design, Development and Assessment of Mobile Clinical Decision Support Systems

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Abstract Clinical decision making is vital for healthcare provision. Sound clinical decision support systems (CDSS) have therefore become crucial for healthcare delivery. This research aims to develop a rubric to guide the design, development and assessment of mobile (i.e., Smartphone or Tab-based) CDSS, combining socio-technological factors and decision-making principles.

Keywords: clinical decision support systems, task technology fit, mHealth, smartphone.

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1 Introduction

1.1 Background

Clinical decision making is a vital component in healthcare. Shortcomings in clinical decision making can lead to medical errors—i.e., human errors in healthcare provision (Makary & Daniel, 2016). Medical errors then lead to adverse health and cost implications (Makary & Daniel, 2016). Therefore, accurate and effective clinical decision making becomes essential.

The complex cognitive process of clinical decision making involves the interplay between knowledge of pre-existing pathological conditions, explicit patient information, nursing care and experiential learning (Banning, 2008). The thought process behind clinical decision making has evolved around a hypothetico-deductive approach, that involves acquiring initial cues, generating hypotheses, and making evidence-based decisions (Banning, 2008), (Jones, 1995), (Barrows & Tamblyn, 1980). Later on, this hypothetico-deductive approach has evolved with the addition of multiple nuances, and has evolved into various clinical decision-making models—some of them involving with Clinical Decision Support Systems (CDSS) as well (Banning, 2008). CDSS have evolved starting from documentation support, to facilities such as electronic medical records, to even more recent developments that provide clinicians the right information at the right time.

Earlier, these CDSS came in the form of paper-based record keeping systems and legacy-based desktop computer platforms (Skyttberg, *et. al.*, 2016). As healthcare evolved further, limitations of such systems as well were identified and requirement and space for further improvement were understood (Skyttberg, *et. al.*, 2016). The call for improvement of CDSS in terms of mobility, interoperability and scalability has become evident (Skyttberg, *et. al.*, 2016), (Ulapane & Wickramasinghe, 2021). At the same time, technology has advanced to facilitate ideal technological capabilities to make these advancements through technology generations like Industry 4.0 (Lasi, *et. al.*, 2014) and Healthcare 4.0 (Wehde, 2019). In such a backdrop, a modern-day interest has become mobile device-based (e.g., Smartphone and Tab-based) CDSS, that have the potential to deliver the technological needs while catering process needs like mobility, interoperability, and scalability. Therefore, an important question faced today, has become how we can design these mobile device-based

systems to best deliver for CDSS requirements. Looking into that question is the focus of this research.

1.2 Motivation

This research is motivated foremost by the shortcomings of clinical decision making that are evident (Makary & Daniel, 2016) and the health and economic implications (Shreve, *et. al.*, 2010) of that. As said before, shortcomings in clinical decision making are a cause of medical errors. Medical errors are: Human errors in healthcare provision (Makary & Daniel, 2016).

The implications of medical errors can be seen well by a 2016 Johns Hopkins study (Makary & Daniel, 2016). According to (Makary & Daniel, 2016), medical errors are the third-leading cause of death in the United States. The projected cost of these errors to the U.S. economy per year has been approximately $20 billion (Shreve, *et. al.*, 2010). From these costs, 87% have been direct increases in medical costs of providing services to patients affected by medical errors (Shreve, *et. al.*, 2010). Another study (Arlen, 2013) points out that medical errors have increased average hospital costs by as much as $4,769 per patient. Some of the burdens posed by medical errors, or shortcomings in clinical decisions can thus be summarised.

Secondly, this research is motivated by the potential of mobile technologies to improve clinical outcomes through enabling better clinical decision making. A good example providing evidence for this potential is the Australian study (Chahal, *et. al.*, 2020). This study reports a work carried out between June 2013 and March 2018, where the efficacy, safety and sustainability of a risk-stratified thromboprophylaxis protocol implemented as a Smartphone App was studied in 24,953 surgical admissions at a dedicated cancer centre. By final implementation, a program compliance of 91% has been observed. A reduction of postoperative venous thromboembolism rates from 3.1 per 1000 surgical admissions to 0.6 per 1000 surgical admissions has also been observed. A decline of postoperative bleeding rates from 10.0 per 1000 surgical admissions to 6.3 per 1000 surgical admissions has also been observed. Sustained improvement has been observed for more than 3 years after implementation. Thus (Chahal, *et. al.*, 2020) has been one promising study that has exhibited how mobile device-based technologies can help improving healthcare outcomes.

Furthermore, since healthcare has some quite well-established workflows that go coupled with years of education and training, introducing digital technology to clinical workflows is not particularly easy. This introduction has been found to carry quite a number of issues as well. These issues however, are not often only technology-related; they tend to be more people and process-related (Ulapane & Wickramasinghe, 2021). Therefore, one of the main challenges of today, is to think about how to do better design, to make best use of technology by understanding and addressing the entailing people and process issues as well. This need for thinking of better design is a third motivation behind this research.

1.3 Scope

The research question revolves around the design and development of clinical decision support systems. As such, the focus is on digital technology-enabled decision support systems in clinical practice.

When it comes to CDSS, there are numerous types including paper-based systems, to legacy-based desktop systems, to more recent mobile device-based (e.g., Smartphone or Tab-based) systems. The call for mobility, ease of use, interoperability and light-weight stand out as important requirements for effective use of CDSS in clinical care (Skyttberg, *et. al.*, 2016). Therefore, the interest nowadays is towards introducing mobile device-based CDSS to healthcare (Ulapane & Wickramasinghe, 2021). Facilitating to that space, the digital health technology focus of this research is mobile device-based (i.e., Smartphone and Tab-based) CDSS. Paper-based and legacy desktop-based systems are out of the scope.

Some of the more serious, and even life-threatening medical errors happen in tertiary and quintenary care where patients undergo treatment under hospital admission (Makary & Daniel, 2016). As such, this research targets that clinical care space (i.e., tertiary and possibly quintenary care). Primary and secondary care will be out of scope. Thus, our technology design will focus on the hospital and ward setting, but not the operating theatre. The target group of technology users will the tertiary care clinicians (specifically, doctors and nurses).

2 Problem statement

2.1 Research question

Motivated by the lack of a systematic approach to develop mobile digital technologies of healthcare, this research explores the possibility for clinicians to use personal and hand-held mobile devices like Smartphones and Tablets in a hospital setting (more specifically, in a tertiary care setting or above) as Clinical Decision Support Systems (CDSS). The related research question can be stated as:

How can mobile device-based CDSS be designed and developed to be more useful and usable for tertiary care clinicians?

2.2 Significance of the research

As said before, shortcomings in clinical decision making can lead to medical errors—i.e., human errors in healthcare provision (Makary & Daniel, 2016). Medical errors can lead to adverse health and cost implications (Makary & Daniel, 2016).

When considering the context of surgery in the above light, postoperative venous thromboembolism (VTE) remains an important cause of morbidity and mortality (Chahal, *et. al.*, 2020). Approximately 2–13 in every 1000 elective surgical admissions in Australia develop a symptomatic postoperative VTE and this is associated with a 10% case fatality rate (Chahal, *et. al.*, 2020). Prevention of VTE remains a worldwide priority safety initiative, with the Agency for Healthcare Research and Quality ranking this the number one patient safety practice for hospitals (Chahal, *et. al.*, 2020). As such, this research is carried out in partnership with a leading cancer hospital in Australia, with the aim of reducing VTE. The specific focus will be to design and develop a Smartphone App (called the CLOTS App) that will help tertiary care clinicians in reducing VTE.

This research will have a contribution to knowledge as well as a contribution to practice. The contribution to knowledge will be a rubric that combines socio-technological factors and fundamentals of decision-making to ensure strong task technology fitness of mobile device-based CDSS. The contribution to practice will be a rubric that can be used by designers, technology developers, change managers,

and other spearheads to guide the design and development, as well as the rating of task technology fitness of mobile device-based CDSS.

3 Literature review

Since this research is about developing mobile device-based CDSS, we are interested in the human activity of clinical decision making and the technology aspect of CDSS. Clinical decision making is a subset of the broader topic of decision making. Furthermore, CDSS are a subset of the broader topic of decision support systems. Therefore, the two key knowledge fields relevant to be reviewed for this research are seen as: (1) Decision making and clinical decision making; and (2) Decision support systems and clinical decision support systems. Then, since we are interested in developing superior mobile device-based CDSS, it is also important to understand the state of the art and the critical issues faced when using mobile CDSS. Therefore, as the third component of this review, a brief analysis of the critical issues faced by mobile CDSS are presented.

3.1 Decision making and clinical decision making

Decision making: Decision making is a cognitive process It results in the selection of a belief or a course of action among several possible alternative options. This process can be rational or irrational. Rational decision making is what is focused on in this research. A common way of classifying decision making involves the following threefold classification: i) Unstructured decision making; ii) Structured decision making, and iii) Semi-structured decision making (Sharma & Thakur, 2015). Next, it is important to know about strategies and procedures followable to perform decision making. These are commonly known as decision-making models. DECIDE (Guo, 2020) and the 7-Step model (Brown, 2012) are two widely accepted generic and rational decision-making models. These models, sometimes with slightly varying terminology, are often taught in leadership and/or management training. Then comes another important decision-making model from Herbert A. Simon's (Simon, 1997). Simon's model can be used to present a perspective that unifies and generalises decision-making models, including the likes of DECIDE and the 7-Step model (Ulapane & Wickramasinghe, 2021). Simon's decision-making model includes the following four main phases: (1) Intelligence phase; (2) Design phase; (3) Choice phase; and (4) Monitor (or Review / Implementation) phase. Simon (Simon, 1997)

also discusses the ideas of Bounded Rationality and Satisficing as undeniable constraints for decision making. The recent work by (Ulapane & Wickramasinghe, 2021) presents a review about decision making models.

Clinical decision making: Clinical decision making is a subset of general decision making. Yet, clinical decision making is a unique process that involves the interplay between knowledge of pre-existing pathological conditions, explicit patient information, nursing care and experiential learning (Banning, 2008). Clinical decisions can mainly be viewed through a two-fold categorisation: (1) Diagnostic decisions (i.e., determining "what is true?"); and (2) Treatment planning decisions (i.e., determining "what to do?") (Wasylewicz & Scheepers-Hoeks, 2019). Historically, two models of clinical decision making have been recognised: (1) The information processing model; and (2) The intuitive-humanist model (Banning, 2008). More recently, a third model of clinical decision making has been proposed, namely, O'Neill's clinical decision-making model (Banning, 2008), (O'Neill, *et. al.*, 2004), (O'Neill, *et. al.*, 2005). The information processing model and O'Neill's clinical decision-making model are both rooted on a hypothetico-deductive approach that assists clinical and metacognitive reasoning (Banning, 2008), (Edwards, *et. al.*, 2004). Thus, the hypothetico-deductive approach can be considered the most enduring clinical reasoning model in medicine (Edwards, *et. al.*, 2004). This hypothetico-deductive approach can summarily be understood via the following four stages: (1) Cue recognition or cue acquisition stage; (2) Hypothesis generation stage; (3) Cue interpretation stage; and (4) Hypothesis evaluation stage (Banning, 2008), (Edwards, *et. al.*, 2004). Not many works have mapped clinical decision making onto the fundamentals of general decision making. Catering to that void, the recent work by (Ulapane & Wickramasinghe, 2021) has presented a perspective for understanding clinical decision making via general decision-making principles.

3.2 Decision support systems and clinical decision support systems

Decision support systems: Decision support systems are information systems-related tools that assist the process of decision making. Decision support systems can be understood as "Inquiring Systems" as proposed by C. West, Churchman (Churchman, 1971). Inquiring Systems can be interpreted as "Systems" that can be put into practice when attempting to solve a problem, or to find a satisfactory answer to a problem. Going with the general interpretation of "Systems"—a System has

Inputs, Outputs, and a Process in between. Similarly, Inquiring Systems too have Inputs, Outputs, and Processes in between. The output of an Inquiring System is "true knowledge", or at least knowledge that can be best agreed upon. A distinctive feature of Inquiring Systems is them containing elaborate mechanisms for "guaranteeing" that only "valid" knowledge is produced. Apply that Inquiring Systems architecture onto an Information System, that would intake several inputs from a user, and outputs knowledge that is guaranteed to be true to some established criteria. Such an Information System essentially functions as a Decision support system. Churchman's work (Churchman, 1971) has discussed several ways of Inquiring by the names of Leibnizian inquiry; Lockean inquiry; Kantian inquiry; Hegelian inquiry, and Singerian inquiry. The recent work by (Ulapane & Wickramasinghe, 2021) argues how clinical decision making quite often aligns with the Lockean inquiry.

Clinical decision support systems: Clinical decision support systems (CDSS) can mainly be classified in the following threefold approach: (1) Diagnostic assistance providing systems; (2) Treatment planning assistance providing systems; and (3) Diagnostic and treatment planning assistance providing systems (Wasylewicz & Scheepers-Hoeks, 2019). There are other lenses as well through which CDSS can be classified according to specific technicalities of the systems (Wasylewicz & Scheepers-Hoeks, 2019). As said in the Introduction, the main focus of this research is mobile device-based (e.g., Smartphone, Tablet) CDSS. Irrespective of how CDSS are classified, and irrespective there being no shortage of technology, some common issues with CDSS are reported in literature. These issues can vary from fitness for purpose of technology, to perception and tendency or lack of it to adoption shown by people. The recent scoping review by (Ulapane & Wickramasinghe, 2021) looked specifically into the critical issues reported in recent extant literature surrounding mobile device-based CDSS. Issues identified can be summarised as: complexity & performance issues; difficulty to validate; cost; data quality; lack of generalisability, expandability, scalability; lack of streamlining with clinical workflow; privacy issues; surveillance capitalism; risks and accountability; policy and legislative challenges; slow or low adoption; personal biases; and competence (or lack of it) in technology (Ulapane & Wickramasinghe, 2021), (Shaw, *et. al.*, 2019). There is also call for better standardisation of mobile health solutions (Lee, *et. al.*, 2018). Despite there being no shortage of technology capability in present times, the emergence and reporting of such a large spectrum of issues related to mobile technology in healthcare evidence

the lack of a systematic approach for mobile technology development for healthcare. Although there are some metrics for this purpose (Mathews, *et. al.*, 2019), they are likely to be developing and not cover a broader and more complete spectrum of socio-technical aspects. Motivated by that gap, this research aims to develop a rubric to guide the design, development and assessment of mobile CDSS in a way superior fitness for purpose is ensured.

Intelligent clinical decision support systems: Clinical decision support systems (CDSS), and more generally most decision support systems that have been developed to assist clinicians often are based on static data which may be out of date. Intelligent decision support systems are an emerging tool that addresses this limitation of static nature that may be there in CDSS. Intelligent CDSS may have artificial intelligent methods which could be applied to actively survey or mine the latest, or updated clinical rules or guidelines. By so doing a decision support system could contain timely updated information for clinicians, which is of significant value in fast changing situations such as minimally understood emerging diseases and epidemics (Ciolko, *et. al.*, 2010).

Table 1: provides a summary of how decision support systems and clinical decision support systems can be scoped

Decision support systems	**Clinical decision support systems**	**Intelligent clinical decision support systems**
Can be viewed as an "Inquiring System"	Can be viewed as an "Inquiring System"	Can be viewed as an "Inquiring System"
Provides "verified" outputs for matching inputs	Provides "verified" outputs for matching inputs, in a clinical context	Provides "verified" outputs for matching inputs, in a clinical context
Traditionally, static in nature (i.e., outputs may be out of date at a particular time of use)	Traditionally, static in nature (i.e., outputs may be out of date at a particular time of use)	An emerging field that uses Artificial Intelligence to address the static problem by actively mining most updated information

3.3 Critical issues with mobile device-based CDSS

The niche for mobile device-based CDSS as opposed to traditional paper-based and legacy-based CDSS systems comes from the need identified for CDSS to be mobile, interoperable, and scalable in order to cater the modern needs (Skyttberg, *et. al.*, 2016), (Ulapane & Wickramasinghe, 2021). Furthermore, the advancements in Internet of Things (IoT) have made it possible to design mobile systems to address the modern needs of healthcare, if the designs can be integrated smoothly with clinical workflows and change management can be handled. However, provided that healthcare has some quite well-established workflows that go coupled with years of education and training, making a technological intervention to a clinical workflow is not particularly smooth, and can result in quite a number of issues. These issues can vary from fitness for purpose of technology, to perception and tendency or lack of it to adoption shown by people. A recent 2021 scoping review by (Ulapane & Wickramasinghe, 2021) found a number of issues reported in recent extant literature about mobile CDSS. These issues can be summarised as: complexity & performance issues; difficulty to validate; cost; data quality; lack of generalisability, expandability, scalability; lack of streamlining with clinical workflow; privacy issues; surveillance capitalism; risks and accountability; policy and legislative challenges; slow or low adoption; personal biases; and competence (or lack of it) in technology.

Moreover, slow adoption rate or the low adoption rate when it comes to adoption of some technology developments in healthcare is a serious issue (Kharrazi, *et. al.*, 2018). There is also call for better standardisation of mobile health solutions (Lee, *et. al.*, 2018).

Despite there being no shortage of technology capability in present times, the emergence and reporting of such a large spectrum of issues related to mobile technology in healthcare, evidence the lack of a systematic approach for mobile technology development for healthcare. That gap stands a motivator behind this research.

4 Theory

In this section, the theoretical lens that will be used to guide this research is summarised. The research question and the specific context in focus deals with introducing a digital health solution to support a healthcare task, and enquiring how this solution can be designed to maximise the benefits to the healthcare task. As such, this work focuses on maximising the fit of a technology (a digital health technology in this context) to a manual task (a healthcare task in this context). A well-known theory that covers our question at hand, is the theory of **T**ask **t**echnology **f**it (Goodhue & Thompson, 1995). Therefore, **T**ask **t**echnology **f**it assessment is taken forward as the primary and an ideal guide for this work.

Then, the target users of this technological tool are tertiary care clinicians as said before. Tertiary care clinicians cannot be taken in isolation and they have to work within and aligned with their work environment—i.e., hospitals and wards. In those environments they do have established workflows. As such, in this context the clinicians must be considered in conjunction with their work environment, or their organisation. Therefore, factors about the organisation needs to be taken into consideration as well, as when the organisational norms are supportive of the introduction of a technology, that will play a key role in successful implementation and eventually help in performance enhancement. Expanding from our baseline theory of Task technology fit, the secondary theory of Fit-viability (Liang, *et. al.*, 2007) helps in forming foundation to assessing how organisational factors play in the success of technology introduction. Therefore, we take the theory of Fit-viability assessment as well to consideration.

The research design (provided in Figure 1 in Appendix 1) has two key phases of research: (1) In-depth analysis of literature, and (2) An exemplary case study. Hermeneutic analytic techniques will be conducted in the in-depth analysis of literature. Then, the case study will follow a positivist approach. Therefore, Robert Yin's case study methodology (Yin, 2017) will be closely followed. Furthermore, since the case study involves designing an artifact, Design science research methodology (Peffers, *et. al.*, 2007) will be followed to guide the design.

5 Methodology

Overview: This study adopts a positivist approach involving methodological triangulation, mixed method analysis, and an exemplary case study.

This research will have two phases. The first phase will focus on an in-depth analysis of literature. Hermeneutic (Kafle, 2011) and Thematic analysis (Boyatzis, 1998) will be used to conduct the qualitative analysis of findings from the literature. The second phase is an exemplary case study surrounding designing a mobile CDSS for tertiary care clinician. This case study will involve: 1) An interview study involving clinicians and requiring written feedback from clinicians after testing beta versions of the App, and 2) A co-design study to improve the CLOTS App. Hermeneutic (Kafle, 2011) and Thematic analysis (Boyatzis, 1998) will be used to conduct the qualitative analysis of the oral and written feedback from clinicians. The co-design study with the CLOTS Smartphone App will involve an Agile App development workflow, based on Design science research methodology (Peffers, *et. al.*, 2007). In addition to acquiring feedback from clinicians, online capturing App usage statistics will also be employed to permit quantitative analysis of App usage trends. The two phases will address the two sub research questions which are:

1. What are the key issues that influence the successful design and development of mobile device-based CDSS as identified in extant literature?
2. What are the key issues that influence the successful design and development of mobile device-based CDSS as identified through end user clinicians' perspectives?

This approach will permit identification of key issues that influence the success of mobile device-based CDSS through two research phases using different research methods. Triangulation of the findings from both phases will result in identification of the key issues to answer our main research question. The two research phases are detailed in the following sections. Figure 1 (in Appendix 1) displays the research design.

Phase 1: In-depth analysis of literature: In this component, extant literature will be systematically reviewed. The purpose will be to identify key factors that influence successful designing and developing of mobile device-based CDSS, and also to articulate an adequate theoretical lens that captures these issues.

Data collection: Data collection will be done by logically creating a search string and performing literature searches in standard medical databases like PubMed, Medline, and Embase. Resulting literature will be screened for relevance first by reading titles and abstracts, and then doing full text analysis of most relevant works.

Data analysis: Data analysis will be done via full text review. This will be carried out through interpretation of texts respecting the hermeneutic circle (Kafle, 2011), and the identified issues will be classified under emerging themes using thematic analysis (Boyatzis, 1998). Since the identified issues are unlikely to be reported as quantitative data, a quantitative bias assessment is likely to be unnecessary, thus, our analysis is expected to be purely qualitative. However, depending on our findings, it might be necessary to do a bias assessment.

Expected outcomes: The expected outcome of this component of the study will be a list of issues and assignable themes. Assessment of the findings is expected to be done through focus groups involving senior clinicians. The findings will form the focus of a peer reviewed paper.

Phase 2: Exemplary case study: This case study will be focused on rebuilding and improving the CLOTS App. The CLOTS App supports prevention of thromboembolism in Oncology surgery patients. The study will follow Yin's case study methodology (Yin, 2017) and design science research methodology (Peffers, *et. al.*, 2007) to facilitate co-design (Steen, 2013). Thus, the question that defines the case study will be: "How can a mobile CDSS be designed and developed to support tertiary care clinicians in preventing thromboembolism in Oncology surgery patients?" Then, the design of the case study will be a single holistic illustrative exemplary case study on improving the CLOTS App.

Data collection: Data collection will be done via two means: (1) Obtaining feedback by clinicians; (2) Online collecting of App usage data. Several app-interfaced online, email, and virtual meeting opportunities will be given to primary users of the CLOTS App to provide feedback and express their expectations regarding improvements to the app. Furthermore, an agile framework will be carried out in redesigning and improving the CLOTS App taking into account good practices reported in literature and the expectations as reported by potential users (i.e., clinicians). Along the agile framework, recording of improvements done, issues encountered, user feedback

received from clinicians, and app usage statistics of primary user clinicians will be carried out.

For the interview and focus group components, ten to twenty clinicians (the sample size is chosen respecting the norms of qualitative interview of experts and the Delphi method (Hallowell & Gambatese, 2010), primarily from the Peter MacCallum Cancer Centre who use the current version of the CLOTS App will be invited to participate in semi-structured interviews regarding their experience with the CLOTS App. The interviews will explore into what clinicians find helpful about CLOTS, what clinicians find as shortcomings, and what are the clinicians' expectations of an ideal mobile CDSS.

Data analysis**:** Clinicians' feedback will be analysed qualitatively. Emerging themes from the interview responses (and other qualitative oral and written feedback provided by clinicians) will be identified, and Thematic analysis (Boyatzis, 1998) will be conducted. The App usage statistics collected will be analysed quantitatively, to find which models in the App are most commonly used, which models and pathways are rarely used, and also potential decision pathway mistake / confusion patterns, and clinicians' usage practices of the App (i.e., for example, as a casual educational tool, or a situation-specific decision support tool).

Expected outcomes: The expected outcome of this component of the study will be a list of issues as identified by clinicians regarding the good design of a mobile CDSS. Assessment of these findings will be carried out through disclosing the findings in focus groups involving clinicians and also unit testing of the redeveloped versions of the CLOTS App. Reporting of these outcomes will be done in the form of one or two articles published in indexed journals.

Lastly, the findings from the two research phases will be triangulated. This would constitute a methodological triangulation, helping ensure quality of and consistency of the findings. These findings will be used to construct a rubric that provides good practice guidelines to help the design and development of mobile CDSS.

The research design is depicted in Figure 1 (Appendix 1).

6 Expected outcomes

Contribution to knowledge: A rubric that combines socio-technical factors and fundamentals of decision-making that need to be considered to ensure strong task technology fit of mobile device-based CDSS.

Contribution to practice: (1) The improved CLOTS App (artifact). (2) A rubric that can be used to guide the design and rate the task technology fit of mobile device-based CDSS.

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Appendix 1: Research design

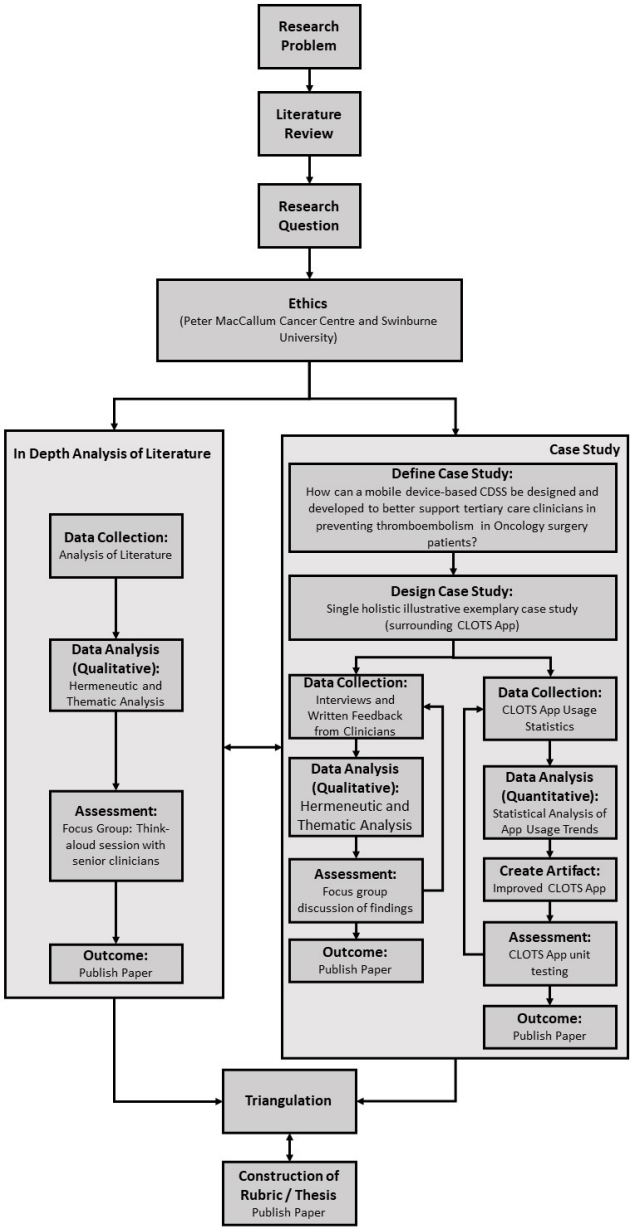


Figure 1: Research design

DOCTORAL CONSORTIUM

AN OPEN ECOSYSTEM OF PLATFORMS ARCHITECTURE TO ACCELERATE INNOVATIONS IN THE 1ST LINE HEALTHCARE

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Abstract Whereas open digital platforms drive innovation in many industries, platforms in primary healthcare are still mostly closed. Policymakers have been looking for ways to open up primary healthcare platforms to stimulate collaboration and innovation and do so even more, given the ongoing COVID-19 crisis. Yet, there is more than one way of opening up platforms in primary healthcare, just as it is unclear how different ways of openness can lead to more innovation. An open digital platform is expected to stimulate innovation, flexibility, and interoperability in information systems in first-line healthcare, but how this can be achieved is unclear. The objective of this research is to understand how to develop an open ecosystem of platforms architecture to accelerate innovations in the 1st line HealthCare.

Keywords: innovation, data sharing, platform, ecosystem architecture, openness, healthcare.

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1 Introduction

1.1 Background

Professional healthcare in The Netherlands is organized in four domains. The zero-line healthcare denotes preventive care measures and healthcare research. The first-line healthcare concerns all professional care that takes place without a need for a prescription. This domain of care for instance involves general practitioners, dieticians, psychologists, physiotherapists, pharmacists, etc. Furthermore, the second-line healthcare involves healthcare that takes place in hospitals. Finally, the third line refers to specialized care, for instance in clinics.

The COVID-19 crisis has painfully exposed that existing digital platforms fall short at supporting caregivers and patients. When caregivers needed comprehensive and accurate data to diagnose, treat, and identify risk groups, they faced low reliability and information availability (EHRIntelligence, 2020a). Even when patient files were digitalized, caregivers often could not access them due to legal constraints and lack of openness between heterogeneous platforms (Lenert and McSwain, 2020).

Besides the COVID-19 crisis there already were several trends that put pressure on the existing healthcare system. First, there is an increasing demand for healthcare support. Second, costs related to healthcare are escalating. Third, the burden of disease is shifting from short term diseases to long-term chronic conditions. Fourth, there is an increasing call to realize patient-centred care.

1.2 Information systems in first-line healthcare in The Netherlands

There is a wealth of information systems involved with first-line healthcare. This section describes how these systems relate to each other and to professional caregivers in this domain of healthcare.

All caregivers in the first-line care domain use information systems to support them in their daily tasks. For instance, general practitioners use a general practitioner information system (Huisarts informatiesysteem, HIS), a pharmacist uses a pharmacist information system (Apothekers informatiesysteem, AIS), etc. These

systems provide functionalities such as: patient treatment logging, a calendar, a cash register, etc. These systems are the focus of this study.
In addition to these systems, there are other applications and infrastructures that extend the information systems in this domain. One of the most prominent examples is the Personal Health Environment (Persoonlijke Gezondheidsomgeving, PGO). These systems are also important for this study, these are the ones to be disclosed via platforms. They are architectural mechanisms that should achieve openness and innovation.

1.3 A digital platform for first-line healthcare

We argue that a vibrant and dynamic ecosystem of third-party service developers is beneficial to the primary healthcare domain. Leveraging the knowledge of third-party developers is expected to lead to increase in innovation efforts for the primary healthcare domain, developing services that benefit both the side of the care givers as well as the patients. In an example situation for a platform-oriented information system in the primary healthcare domain, the platforms' core contains core functionality that is shared among all participating parties (e.g., logging patient treatments, authorization, identification). Additionally, complementors can offer modules that can be coupled to the platforms' core. These modules may mediate between user groups, adding values to different actors in the ecosystem. In this example, an independent software developer may add an application to the platform by using interfaces and boundary resources, e.g., APIs and SDKs (or boundary resources) that are provided by the platform owner.

Example 1:

In the example a developer may have the idea for an IoT medicine box that can track what medicine a patient takes in. This exact intake can be monitored. While this is useful for the patient, it may also allow the patient's pharmacist and general practitioner to keep track of the medicine take in and health status of the patient. This way, the caregivers can give accurate support to the patient.

Example 2:

A patient makes use of his mobile phone camera to keep track of complaints concerning a mole on his/her skin. The picture can be sent to a general practitioner. Simultaneously, this picture may be analyzed through a specific add-on module created by a third-party developer, comparing it to pictures of moles of other patients. Information regarding this analyzed picture can assist the general practitioner in making a decision that he/she can discuss with the patient.

2 Theoretical background

2.1 Digital platforms in healthcare

Digital platforms may benefit the healthcare domain. For one, they can reduce fragmentation of applications by integrating different IT-services through a platform (Furstenau et al., 2018). Secondly, digital platforms show powerful innovation capabilities (Boudreau, 2010), possibly solving the lack of innovation in healthcare (Furstenau et al., 2018). Furstenau et al. (2018) study how the technical design (architecture) of a digital platform and its governance structure can be developed to develop a digital platform in healthcare in the U.S. They come up with a framework for how a platform owner can set out to develop a digital platform in healthcare. Furstenau et al. (2018) propose several avenues for future research on digital platforms in healthcare:

1. The reconstruction of the process of platform design. In this research we do more extensive, comparative studies across different platforms and initiatives.
2. Longitudinal research over a timeperiod. An option may be to look at later phases of platform development and to examine for example how ecosystem extension continues.
3. Each of the areas of the framework of Furstenaui et. Al (2018) warrants further research. In the research we want to develop more feedback loops to dive deeper in the framework and outcomes.
4. Industry and ecosystem studies are important to understand platform competition and market dynamic. We expect platform competition and platform battles as strategies for market domination and consolidation like in other industries."
5. The impact of digital health platforms on national health systems is an interesting area of study.

6. Explore the effects of digital health platforms on the performance of health care delivery We suggest interdisciplinary and longitudinal research designs to monitor and analyse these developments."

In a work on how to reduce the silo-structure of IT in healthcare in a hospital-setting (different care departments have separate IT systems), Bygstad et al. (2015) study how a platform can integrate the IT systems in the different silos. They show that an integration platform can reduce complexity, because it reduces the number of interdependencies and information can be handled more easily between the different silos. However, in the long term such platforms may become increasingly difficult to govern due to the involvement of different parties, threatening stability of the system. They suggest future researchers to "investigate complementary and alternative solutions to the IT silo problem. Strategies for reducing complexity typically include modularizing and loose coupling (Parnas, 1972), or, in other terms, trying to make it simple by reducing the number of relationships. In practice this will mean to integrate less, and to integrate more loosely. The question, then, is: how do we sort out what can remain as IT silos, and what can be more loosely integrated? Can we rethink the silo problem by a looser coupling between clinical systems and work process support? The welcome benefits from this approach would be (i) that process support could be designed much closer to the clinicians and (ii) that the clinical silo systems could continue their life as silos." In a follow-up research, Bygstad and Hanseth (2018) study platformization, how to transform a siloed IT-organization towards a platform-based system. They show how establishing of boundary resources and a data-layer are crucial steps in platformization. In addition, they state that organization of architecture and governance through boundary resources is crucial in giving the platform owner control over the ecosystem.

2.2 Openness and strategy

A platform's mode of openness can have significant consequences for the platform owners' strategic goals. As a clear example, Van Alstyne et al. (2016) find that too little openness can limit network effects which may lead to the failure of a platform. Too much openness on the other hand may also have destructive effects due to loss of quality or misbehaviour of platform participants. This paragraph discusses some of the strategic issues relating to choosing openness of a platform.

Openness and complementor engagement – Benlian et al. (2015) find that the perceived openness of a platform affects how complementors choose to contribute to a platform. They say that openness of the platform will lead to greater willingness to contribute, thus greater innovation in complements.

Openness and launch strategy – At what side to open the platform, at the demand-side user or the supply-side user? If a platform fails to onboard a critical user, e.g., that of the caregivers, they will have a difficult time to onboard other users to the platform (Van Alstyne et al., 2016). De Reuver et al (2018) also study the role and effectiveness of platform launch strategies

Openness and critical mass – A critical mass of actors is crucial for the adoption of a platform. A platform should seek to reach the tipping point to get a sufficient group of users to board the platform. Ondrus et al. (2015) show that openness can lead to greater user adoption.

Openness of the platform (core) itself can lead to greater quality, as multiple developers contribute to making improvements in the codebase (Brunschwiker & Schechter, 2019). Openness of the core however may also come at the cost of loss of stability and predictability (Brunschwiker & Schechter, 2019) and may even result in applications rendering useless (Wareham et al., 2014).

2.3 How to define openness through the platform architecture

Platform architectures can be configured in different ways (Blaschke et al., 2019; Kazan et al., 2018). Varying platform architectures result in varying platform behavior over both the short- and the long term. The complexity of a platform's architecture impacts the complementors perception of how attractive it is to innovate on a platform. A platform owner faces a trade-off on the complexity of its platform architecture.

- Cennamo et al. (2018) find that the simpler architecture leads to (+) greater innovation in the complements, but also to (-) higher fungibility of the platform. Moreover, a more demanding architecture makes a platform (+) more unique, but also (-) requires greater effort from the complementor.

- Aulkemeier et al. (2019) study how collaboration between different information systems in one context can better cooperate. They find that a platform can successfully coordinate collaboration between different existing users. It allows both easy coupling and decoupling of functionality, without harming other functions affiliated with the platform. Furthermore, it can enhance data exchange between different systems.
- Saadatmand defines platform taxonomies based on the openness of their architectures on four dimensions. On these dimensions, they see different modes of organization and openness. On the bases of these configurations, they find three taxonomies of different platforms. Service: oriented at, Ecosystem, Core or Infrastructure.

Companies in a platform ecosystem are mutually dependent for the survival of the platform (Alves et al., 2018). Governance should seek to balance the interest of the involved parties for long term sustainability.

- From Benlian et al. (2015) perceived platform openness (PPO) to the complementors determines how attractive a platform is to complementors and, as a consequence, determines the innovation that takes place on a platform.

Boundary resources serve as a means to integrate developments by third parties with a digital platform's core. Moreover, boundary resources govern the relationship between the platform and external developers (Hein et al., 2019)

Boundary resources are related both to architecture and to governance (Schreieck et al., 2016). Boundary resources are the "the software tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and the application developer" (Ghazawneh & Henfridsson, 2013). Moreover, boundary resources mediate access to the platform's core (De Reuver & Van der Wielen, 2017).

Important mechanisms to achieve openness, without fully giving up control over the technology, are boundary resources.

2.4 Scientific research gap

This research extends scientific work on the relationship between platform architecture, platform openness and the rate of innovation. Blaschke et al. (2019) and Kazan et al. (2018) requested future researchers to explore the understanding link between platform architecture configurations and achieving strategic goals. This research has the aim to show how potential platforms can clarify innovation attractiveness by considering different mechanisms of openness for a platform architecture.

Design science research literature states that rigorous design needs to account for a class of problems in order to be valid outside the boundaries of its original environment (Hevner et al., 2004).

An approach to achieve this is the meta-design approach. consisting of three subsequent stages. First, a core theory is identified to underpin the design process. Second, of the constructs provided by this theory, meta-requirements are identified and systematized. Third, a meta-design is created to take into account the identified meta-requirements.

The conceptual model, in figure 1, shows the relations between the research objective and the research questions, meta design and meta-requirements.
It shows the relation between openness how it contributes to innovations and how to design openness.

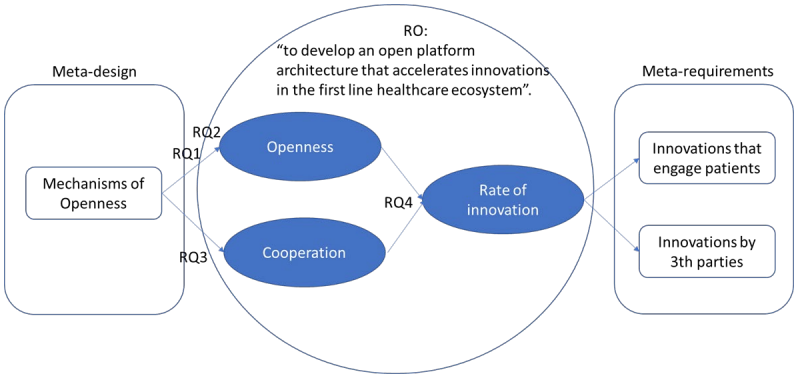


Figure 1: Conceptual Model

3 Research

3.1 Research objective

Considering the preceding discussion, the research objective is "to develop an open platform architecture that accelerates innovations in the first line healthcare ecosystem".

3.2 Research questions

RQ1: `What are possible forms of platform openness in first line healthcare, and how do these affect innovativeness'

RQ2: What influences the openness of the architecture in the 1st line healthcare?

RQ3: How to compile, with forms of openness, an open architecture that improves cooperation in the 1st line healthcare of patients?

RQ4: Does the use of this open architecture accelerate the number of innovations in the 1st line healthcare?

The relations between these research questions are visualised in figure 1, the conceptual model.

3.3 Research approach

The intended outcome is a working proof of concept that shows the design choices that platform owners have for choosing platform architectures with different degrees of openness realizing more innovations. Based on this PoC, experts should be able to express their perception of this platform architecture will be suitable to drive innovations in first-line healthcare.

Intended method at this stage:

A combination of methods will be used to design the Proof of Concept as a working prototype to demonstrate the proof.

Firstly, following DSR-suggestions by Johannesson and Perjons (2014) and Peffers et al. (2007), the purpose and intended

outcome of the PoC is made explicit. This done with defining the requirements the PoC must meet.

Secondly, brainstorming must take place to develop ideas with other architects and healthcare profesionals for the PoC (inspired by an approach from Johannesson and Perjons (2014).

4 Final document

The final product of this research will be a collection of 3-4 papers, with an overarching introduction and conclusion section. This report, which consists of six chapters. We will begin in Chapter 1 by introducing practical and scientific problems at hand as well as objectives and an overview of our research design. There will be an overview of core concepts used in this research, Openness, digital platforms, architecture and boundary resources. The purpose in this chapter is to outline knowledge gaps in literature streams as well as the relations between these concepts. Chapter 2, will be the first scientific paper, answering RQ1. *More than one way to open platforms and solve the innovation challenge in primary healthcare.* Chapter 3, will be the second scientific paper answering RQ2. What influences the openness of the architecture in the 1st line healthcare? Chapter 4, will be a design of the architecture, answering RQ3. an open architecture that improves cooperation in the 1st line healthcare of patients. In Chapter 5, we will develop an open architecture that improves cooperation, implement it in a pilot situation and evaluate if this accelerates the number of innovations. Finally, in Chapter 6, we will answer our research questions by elaborating on our main findings as well as discussing theoretical and practical implications for the 1st line healthcare. In the end, we will outline several limitations of our study and suggestions for future research.

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DOCTORAL CONSORTIUM

THE OVERVIEW OF THE SMART PUBLIC GOVERNANCE CONCEPT

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Abstract **Purpose**– the purpose of this conference paper is to present to the reader a systematic overview of the definitions of the smart public governance (SPG) concept in the presented literature. In the field of social sciences, it is possible to find various definitions of the concept, however, their number is scarce, since the concept is relatively new in the literature and still in development. The main objective of this conference paper is, therefore, to provide a thorough theoretical overview of the definitions of SPG in the available literature, and on this basis, upgrade the existing table of definitions and attributes of the concept from 2015. **Design/methodology/approach**– the approach of this conference paper is to provide a comprehensive theoretical overview of the definitions of the SPG concept in the literature in the field of social sciences between 2015 and 2021. **Findings**– when interpreting the concept of SPG, most scholars do not rely on just one attribute but interpret it on the basis of various attributes. The review of the papers has shown that the scholars relate the concept of SPG mostly with the attributes of external collaboration and participation, the decision-making process, and information-communication technology.

Keywords: public governance, smartness, smart public governance.

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1 Introduction

This conference paper is conceptual in nature, and its purpose is to raise interest and support a developing discourse on the complicated topic of smart public governance (hereinafter referred to as SPG) concept. In doing so, this input is based on the existing research from 2015 by Bolivar and Meijer, which has theoretically and empirically explored the concept of SPG over the past decade.

Since the beginning of the 21st century, government and politics globally have been facing several complex and closely tied challenges such as the third industrial revolution, lack of effective and timely interventions, increasingly rapid changes, and high prices of government expenditures together with public debt financing. In their efforts to address these dynamic economic or societal pressures associated with the complex challenges of public policies, governments and societies around the world are gradually seeking strategies to address them, with the desire to be able to respond as quickly as possible. An important aspect of this scenario in recent years is SPG, a vital governance system for these pressures (Scholl & Scholl, 2014, pp. 163-164; Šiugždinienė, Gaule, & Rauleckas, 2017, p. 1). In this context, the concept of SPG has begun to be applied in the field of social sciences in various aspects. Despite the significant interest in SPG over recent years, in fact, the definition of what this concept refers to remains an open research topic. Scholars lack a general view of the concept of SPG, which integrates different contexts in the field of social sciences (Bolivar & Meijer, 2016). This is not surprising, as the term has only been present in the scientific literature for a short time. In general, several research papers exploring the concept of SPG can be found in the literature related to the local government level, especially in cities and regions (Meijer & Bolivar, 2015). Nevertheless, most papers do not consider a general view that is independent of the local government level. Coming to a decision on the definition of the SPG concept is quite challenging, as the latter represents the entire governance process, including government structures and their processes (Šiugždinienė et al., 2017) (in Vujković et al., 2022).

In short, to our best understanding, there is no consensus on the conceptualization of SPG as well as its attributes with respect to common points regarding how they are used in different contexts in the scientific literature. The first step to achieving the key objective of the conference paper was clearly to capture an understanding of the two key concepts that make up the concept of SPG. Therefore, in the

continuation of the introduction, we present the building blocks upon which the concept of SPG is constructed: the concept of (public) governance (1.1.), and the notion of smartness (1.2.).

1.1 The concept of (Public) Governance

Like most concepts that can be found in literature in the field of social sciences, the concept of governance is not new and is now a well-accepted concept in the social sciences (Bovaird & Löffler, 2015, p. 163; Osborne, 2010, p. 6; Turnšek -Hančič, Červ, & Bačlija, 2013, p. 12) - despite the first limited role in shaping debates within the social sciences (Levi-Faur, 2014, p. 5). While nowadays the term is indeed found in many fields, the term was first introduced to the social sciences by researchers of international relations (Bačlija, 2013, p. 7). In the 1950s and 1960s, the concept of governance was considered as a marginal term that had only recently reached its present glory (Torfing, Guy-Peters, Pierre & Sørensen, 2019, p. 12). The few papers classified under this topic in the social sciences during this time focused mainly on higher education. Later (that is, in the late 1970s), the situation changed radically, with the emergence of the term governance in private sector debates (Levi-Faur, 2014, p. 5).

In recent decades, the concept of governance has become one of the most commonly used terms in the social sciences (Katsamunska, 2016, p. 133; Torfing et al., 2019, p. 2), which Levi-Faur (2014, p. 7) attributes to the fact that the scholars began to study changes, thus becoming more open to new paths, concepts and questions. Notwithstanding the fact that the concept of governance can be seen today in countless titles of books and articles, as well as in the names of academic journals and educational institutions, it is practically impossible to find a common consensus among scholars on its definition (Offe, 2009, p. 554).

The development and growing use of the term governance in the current literature are associated with globalization, public sector reforms and changes in the relationship between the state and civil society (Bačlija, 2016, p. 23). The term is often used today by both policymakers and international institutions (Guy-Peters: in Levi-Faur, 2014, pp. 19–44), which links the concept of governance to the interaction between policymakers and stakeholders, the knowledge-based decision-making process, smarter policy solutions and coordinated policy implementation.

Both Katsamunska (2016, p. 133) and Bačlija (2013, p. 7) attribute the popularity of the term governance in contrast to its related (but narrower) term government to the fact that the term governance encompasses many institutions and relationships involved in the governance process and has recently become significantly more attractive and useful than the concept of government.

In Slovenia, a single naming solution has not yet been established for the concept of governance. The Dictionary of the Institute of the Slovenian Language states that governance is a verb for governing but explains it as an activity that deals with arranging and directing life in a social community (in Fran SSKJ; Pečarič, 2011, p. 39). In this conference paper, the translation of *public governance* will be used as an appropriate translation of the term *governance*. It will be understood as a *decision-making process or activity of society and organizations in public affairs, within which goals are set and decisions are made, and people are coordinated in order to achieve the set goals*. Nevertheless, the concept of public governance has several meanings in the domestic (that is Slovenian) literature. In the following Table 1, the reader can read some selected definitions of the concept of public governance by Slovenian scholars.

Table 1: Selected definitions of the concept of public governance by Slovenian social science authors

Author/s	Public governance definition
Bučar (1969, p. 11) (legal sciences)	Public governance is »/…/ deciding on needs and on the manner of satisfying these needs. «
Lorbar & Stare (1998, p. 14) (administrative sciences)	Public governance is »/…/ directing or setting the direction [...] and is always linked to a specific goal, and it is also an activity that enables the achievement of a specific goal. «
Virant (2004, p. 16) (legal and administrative sciences)	Public governance is »/…/ determining the goals of the organization and directing the activities of the organization towards achieving these goals. «
& p (administrative sciences)	Public governance is »/… / the process of leading and guiding organizations from goal setting to their realization and feedback. «
Grafenauer & Brezovnik (2006, p. 37) (legal sciences)	Public governance is »/…/ an activity the essence of which is in directing, setting the direction for achieving a certain goal. «
Pečarič (2011, p. 22) (legal and administrative sciences)	Public governance is »/…/ deciding on goals and using the most appropriate means to meet them. «
6p (political sciences)	Public governance is »/… / the process or manner of decision-making in society. «

Source: Author's own table.

According to the interpretations of public governance in Table 1, we can see that scholars in the field of social sciences in Slovenia use different methods of translating and defining the concept. Interpretation of the concept of public governance is most often associated with a) setting objectives, and b) directing the work of organisations towards the set goals.

1.2 The concept of Smartness

We may observe that in the last two decades the term smart has become extensively used in various sources by academics and practitioners. Both the frequent use of the term and all its derivatives can be attributed to the fact that in different sources term reflects different meanings (Juceviciene & Juceviciene, 2014, p. 911; Gil-Garcia, Pardo, & Nam, 2015, p. 63). Even though the research definitions of smartness have recently become increasingly popular, different scholars still interpret this term very differently. The phrase frequently appears in several sources, each with a different meaning. One of the reasons for this diversity is that there is no universally accepted definition of smartness among scholars. The second reason is the language of scholars. The term "smart", for example, is used in the Anglo-Saxon area to describe the characteristics of smartness of technical and social objects. At the same time, smartness can be described in different ways in many other languages (Jucevicius & Juceviciene, 2018; Buškevičiūtė, 2014; Juceviciene & Jucevicius, 2014).

What does smartness represent? When trying to figure out what smartness is all about, answering that question is critical. People are the primary stakeholders in any social system, such as a state or a city (Jucevicius & Juceviciene, 2018; Rosen, 2003). Because smartness involves a good understanding of communities and constituencies (i.e., being receptive) and accurate assessment of a certain situation or people (i.e., being smart), people have a keen ability to judge (i.e., be prudent) and make decisions and to respond quickly or effectively to change (i.e., being fast), which is considered in the literature of the present time as a desirable aspect of governments, cities, communities, infrastructure, and organisations (Gil-Garcia, Zhang, & Puron-Cid, 2016). Some definitions place a strong emphasis on technology and data, while others emphasise sustainability, openness, creativity, and resilience. As a result, the idea of smartness incorporates aspirations for the public sector to become more resilient and agile through the adoption of the emerging technologies, as well as positive assumptions such as interconnection, efficiency, sustainability,

effectiveness, transparency, and collaboration. Being smart is not an aim in itself, but rather an enabler of other desirable social, economic, or environmental consequences (Gil-Garcia, Helbig, & Ojo, 2014; Nam & Pardo, 2014) (in Murko & Vujković, 2022).

However, in the beginning, smartness emerged as a desired feature of cities and devices afterwards government and governance, leading to many different perspectives of the concept itself in the present literature (Gil-Garcia et al., 2014; Gil-Garcia, Pardi, & Tuja, 2021). The expansion of the study of smart technologies to other scientific fields and sciences (although still primarily a technological concept) has given the concept of smartness its multidimensional features (Criado & Gil-Garcia, 2019; Gil-Garcia et al., 2016). By this logic, the growing role of smart technologies today is considered as the technologies that allow users to connect to Internet networks (Papadopoulou & Maniou, 2021). Despite this very simplistic definition of smart technologies, the artificial intelligence, the Internet of Things, blockchain technology, cloud computing and machine learning are nowadays considered ambassadors of smart technologies, sometimes in present papers referred to as emerged or disruptive technologies (Kankanhalli, Charalabidis, & Mellouli, 2019; Wirtz & Müller, 2019) (in Vujković et al., 2022).

In summary, the vital objective of this study is to give rise to accurate basis for debate by presenting an overview of what is known about the SPG concept. We extensively read the definitions of the SPG concept presented in scientific papers and put a specific focus to group them in terms of the attributes that showed the similarities. To that end, we have conducted a Systematic Literature Review aiming to retrieve papers that contain definitions of the SPG concept. The search is carried out depending on the social science field in which the definitions are presented. The definitions are then manually extracted from the collected papers to obtain the results.

The conference paper is organised in four sections, including this introduction section. The rest of the paper is structured as follows: in the next section, we introduce our problem definition. Section three describes the methodological approach used for our theoretical overview. In the last section, we present what the existing literature reveals about the SPG concept and highlight the major contextual factors.

2 Problem definition

The purpose of this conference paper is to present to the reader a systematic literature review of the definitions of SPG concept in the present literature relating to social sciences. Accordingly, the conference paper aims to provide a thorough theoretical overview of the definitions of the term in the available literature as well as to update the existing table of attributes of the SPG concept from 2015. For this reason, the following research question has been formulated to guide our research:

1. *How is the concept of smart public governance understood in research papers published between 2015 and 2021?* This research will not create a single definition but will include an overview of the different definitions of the SPG concept. The papers from the field of social sciences will be examined in order to further differentiate the defining attributes of the SPG concept.

3 Methodology

Intending to address the research question formulated above, we carried out the analysis of the content of the records in the Scopus database. The steps of the systematic review are presented in Figure 1. Since we have a small sample of records, we have applied a qualitative research approach to the conference paper. The following two subsections give a detailed description of the methodological steps.

3.1 Inclusion and exclusion criteria

To extract definitions of the concept of SPG from the existing literature, we conducted a content analysis of records in the Scopus database. First, in the query title, we used the terminology of "smart public governance" or "smart governance" as titles, abstracts, and keywords. After the initial search, the records were further selected according to the following criteria:

- time of the records: between 2015 and 2021,
- category: social sciences,
- written in English.

3.2 Data collection

The detailed search resulted in 143 records. The next step was to review the records, which included reading the titles, abstracts, and keywords of the records. In this part, we excluded from further analysis those records which did not address the concept of SPG. A systematic review of the literature enabled us to identify 15 records, which we read completely. 3 more records were excluded (those that did not include any explanation of the concept of SPG after 2015 – which is the subject of this conference paper). Finally, 12 records (Figure 1) were included in an in-depth analysis. These are articles, conference contributions and book chapters based on which we have established a table with the definitions of SPG (Table 2).

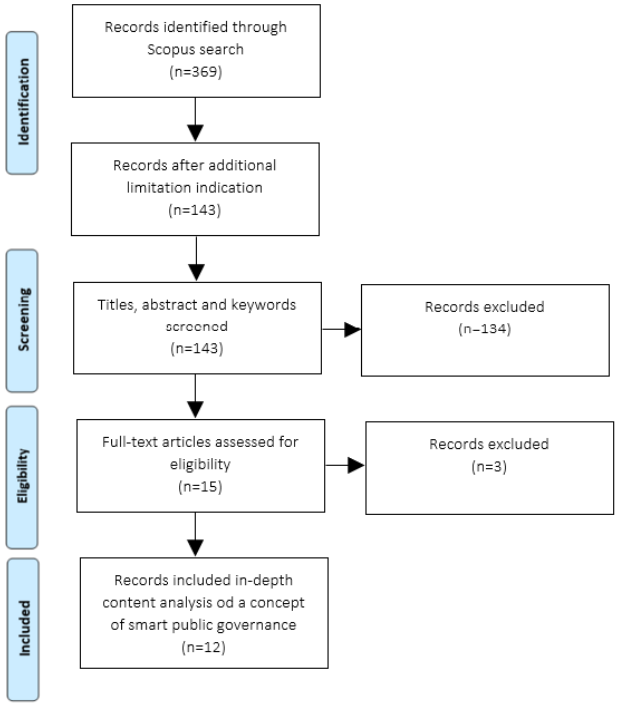


Figure 1: Flow diagram representing the collection of articles in databases and filtering process

Source: Author's own figure.

4 Preliminary results

Table 2 below shows different interpretations of the concept of SPG in the social science literature, which consists of 12 records published in studies that have been written on various topics (especially topics related to smart cities) and covered the operationalization of the concept. The conference paper aims to provide a comprehensive theoretical review of the definitions of SPG in the available literature; and also, to upgrade accordingly the existing table of definitions and the attributes of the concept of SPG by Bolivar & Meijer (2016). According to the study, the innovation attribute was recognised (by representatives of the European local government) as a new attribute. Furthermore, the authors explain that, while it is an attribute that is often mentioned concerning smart cities, it is not perceived in literature as one of the attributes of SPG. We have decided to include the latter in the table as well.

Table 2: Definitions of SPG concept from available literature published in the period between 2015 and 2021

Author	Definition (object)	Level			Attributes of the Smart Public Governance						
		City	Public Administration /Public Sector	State	Based on ICT	Based on External Collaboration and	Based on Internal Coordination	Based on Decision-Making Processes	Based on e-Administration	Based on the Outcomes	Based on the Innovation
(Recupero et al., 2016) in (Anthopoulos, 2017, p. 269)	»/…/ smart (public) governance is a dimension of smart city, which measures local smart government performance with the following indexes: participation in decision making; public and social services; transparent governance; and political strategies and perspectives.«										
(Glasmeier & Christopherson, 2015) in (Paskaleva et al., 2017, p. 4)	»/…/ smart (public) governance is considered core to smart cities and includes citizen participation in sustainable collaborative processes based on ICT.«										

(Albino, Berardi, & Dangelico, 2015) in (Pereira et al., 2017, p. 2)	»/…/ smart (public) governance means various stakeholders are engaged in decision-making and public services.«										
Šiugždiniene, Gaule, & Rauleckas (2017, pp. 3-4)	»/…/ smart (public) governance is the mode of governance that relies on rationally utilizing internal and external resources, making adequate progress, and making advanced decisions relevant to specific circumstances in order to create shared value (Gaule et al., 2014), with the goal of making a social system (country, region or city) and its actors (government, citizens, communities, businesses and non-governmental organizations) operate effectively in a fast-changing and complex environment.«										
(Razaghi & Finger, 2018) in Anindra et al., 2018, p. 2)	»/…/ smart governance is understood as an enabler to develop a smart city, where smart governance in relation to smart city is better management of data usage and community involvement for quick and effective decision making.«										
Nesti (2018)	»/…/ smart (public) governance entails the adoption of a new approach based on experimentation, collaboration with all local stakeholders and the reorganisation of existing government structures.«										
(Scholl & Alawadhi, 2016) in (Pereira et al., 2018, p. 143)	»/…/ smart (public) governance is defined as the capacity of employing intelligent and adaptive acts and activities of looking after and making decisions about something.«										

Pereira et al., (2018)	»/…/ smart (public) governance is defined as the ability of governments to make better decisions through the combination of ICT-based tools and collaborative governance. In this sense, we understand that smart governance is the use of evidence (data, people, and other resources) to improve decision making and deliver results that meet the needs of the citizens.«										
Webster & Leleux (2018)	»/…/ smart (public) governance is where municipalities and citizens engage, interact and co-produce using ICTs and social media.«										
(Jiang et al., 2019) in (Jiang et al., 2019, p. 246)	»/…/ smart (public) governance is a way to take advantage of various ICTs, aimed at bringing changes in public policy and government institutions from a public administration perspective.«										
Simonofski, Snoeck, & Vanderose (2019)	»/…/ smart (public) governance is one of the key dimensions of a smart city and underlines the importance of an increased collaboration within governmental bodies and an increased co-creation of e-government services (or smart city projects) with users.«										
(Meijer, 2016) in (Jiang et al., 2020, p. 4)	»/…/ smart (public) governance is about developing innovative governance structures through the use of newly emerging technologies and new channels of communication to make cities smarter.«										
(Barns et al., 2017) in (Ranchod, 2020, p. 3)	»/…/ smart (public) governance is centred on the nature, type and use of data to enhance evidence-based decision-making for improved public management.«										

(Rodriguez et al., 2015) in (Ranchod, 2020, p. 3)	»/…/ smart (public) governance prompts greater collaborative governance through the inclusion and participation of civic actors in urban decision-making processes.«										

Source: Author's own table.

A theoretical review of the literature focused on the interpretation of the concept of SPG has shown that the conceptualizations of the latter in the literature in the field of social sciences are still very sparse. It is (still) the most commonly interpreted in literature in the records dealing with topics related to smart cities (i.e., at the local government level). It was expected that the concept of SPG will be more frequently interpreted in records dealing with smart cities because, as Vujković et al. (2022) state, in the bibliometric research in the field of SPG, those studies that are related to smart cities predominate. Furthermore, the author states that also (especially in recent years), the studies relating to the smart government are coming into focus.

Bolivar & Meijer (2016, p. 9) state that in the interpretation of the concept of SPG the large majority of authors do not take into account only one attribute, but interpret the concept based on various attributes, which according to the review of the concept interpretations in the available records, we have also seen. In our case, the highest value in the interpretation of the concept of SPG was given to a) external collaboration and participation; b) the decision-making process, and c) the information-communication technology. Only three records, mention the e-administration within the interpretation of the concept of SPG, two records mention the outcomes and one record the innovation. The latter was also rated rather low by the representatives at the central government level in a study by Šiugždiniene et al. (2017, p. 17). Interestingly, in our case, internal coordination has not been mentioned at all within the interpretation of the concept of SPG. As the research contributes to a better understanding of the concept of SPG, data from various sources could be used to achieve the goal of this conference paper. Although Scopus is often considered to be the most extensive database of peer-reviewed literature in the world, it may not represent a complete research collection of interpretations of the SPG concept. Using different databases, such as Google Scholar or WoS, could

provide additional insights not found in this study. Second, the study examined only English titles, abstracts, and keywords, which could lead to bias in publishing.

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This conference paper brings together the work, which will be implemented as part of the doctoral thesis "Development of a model for smart public governance maturity measurement support", firstly to develop an innovative artefact (i.e., model) to support a measurement of the maturity level of smart public governance, and then with the structural interviews test it in the Slovenian public policy context.

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35TH BLED ECONFERENCE DIGITAL RESTRUCTURING AND HUMAN (RE)ACTION

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Abstract The Bled eConference, organised by the University of Maribor, Faculty of Organizational Sciences, has been shaping electronic interaction since 1988. After 2 years COVID-19 pandemic, when the conference was held online, this year we met again in Bled, Slovenia. The theme of the 35th conference is "Digital Restructuring and Human (re)Action". During the pandemic, we experienced the important role of digital technologies in enabling people and enterprises to interact, collaborate, and find new opportunities and ways to overcome various challenges. The use of digital technologies in these times has accelerated the digital transformation of enterprises and societies. It will be important to leverage this momentum for further implementation and exploitation of digital technologies that will bring positive impacts and solutions for people, enterprises and societies. The need to achieve sustainability goals and sustainable development of society has increased. Digital technologies will continue to play an important role in achieving these goals. The papers in this conference proceedings address digital transformation of enterprises, digital wellness and health solutions, digital ethics challenges, artificial intelligence and data science solutions, new and digital business models, digital consumer behaviour and solutions, including the impact of social media, restructuring of work due to digital technologies, digital education challenges and examples, and solutions for smart sustainable cities.

Keywords: digital restructuring, human, reaction.

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