Design Science Research in Business Innovation

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1 Theorizing Business Innovation

From a process perspective, business innovation is the systematic planning and control of innovations in organizations or in networks of organizations. The primary objects of business innovation are products and services, business processes, and business models. Assuming that the primary goal of research in business innovation is theorizing, the classification of Gregor (2006, p. 622) can be applied to differentiate the following types of business innovation theories:

- **Theory for Analysis**: Says what is. The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made. An example is a taxonomy that differentiates management approaches in a certain domain according to certain context aspects, goals, etc.
- **Theory for Explanation**: Says what is, how, why, when, and where. The theory provides explanations but does not aim to predict with any precision. There are no testable propositions. An example is a model that assigns certain success factors to a management domain.
- **Theory for Prediction**: Says what is and what will be. The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations. An example is a model that assigns a maturity level to a specific management practice and predicts the respective performance based on empirical observations of similar practices on that maturity level.
- **Theory for Explanation and Prediction**: Says what is, how, why, when, where, and what will be. Provides predictions and has both testable propositions and causal explanations. An example is a model that explains the factors that determine the use of an IT

system and allows to predict the acceptance of a specific IT system using the proposed causal relationship.

- **Theory for Design and Action**: Says how to do something. The theory gives explicit prescriptions for constructing an artifact. Examples are methods, techniques, principles of form and function for which can be asserted that their application will solve a certain class of design problems in organizations.

The first four types of theory comply with the tradition of social sciences (e. g. Kerlinger 1964; Dubin 1978). Business innovation is theorized as an empirical phenomenon in order to generalize analyses, explanations, and/or predictions. From the perspective of these ways of theorizing, business innovation phenomena are not distinct from other phenomena in organized systems and hence require no specific methodological attention.

Theories for design and action are different. Dealing with artifacts, they relate to the sciences of the artificial (Simon 1996, p. 3). In contrast to the traditional dominance of the quest for analyzing and understanding the present world in many natural as well as social sciences (e. g., physics or sociology), sciences of the artificial (e. g., medicine, engineering, or architecture) do not aim to explain the current world, but rather to change it into a better or preferred one. Since business innovation research belongs to business research and thus to social sciences, such an "improvement" or "problem-solving" perspective is sometimes not regarded as science, but instead as a complementary concept of "design".[1]

The differentiation of "science = understanding" (or explaining or predicting, without any application intention) on the one hand, and "design = improving" (or creating or problem solving, always with a purpose) on the other, however, might be misinterpreted as a qualitative differentiation between scientific activities on the one hand, and practical activities ("applied research" or even "consulting") on the other. In this regard, Simon's seminal work was a much needed recognition of design and engineering as scientific, and not practical activities.

Since research in business innovation is not different from other business research disciplines as long as the understanding perspective is taken, and the first four types of theorizing are intended, we focus on the specific 'improvement' perspective, and thus on theories for design and action, in the following. Although design elements need to be combined with engineering elements and even traditional explanatory research in this perspective, we follow the traditional designation of this particular research approach as 'design science research'.

Design science research as described in the article at hand provides a foundation for the business innovation processes in general and for the process steps of idea generation, design, test, and launch in particular. The business innovation model's dimensions of products and services, processes, and business models are typical artifacts that are the result of a design science research project. These artifacts can often be configured to fit

[1] An example is the proposal to extend organizational science by organizational design by Romme (2003).

different contexts defined by the spheres of organization and culture, as well as by the competitive environment.

The article proceeds as follows. In Sect. 2 we position the central paradigm of this article – Design Science Research (DSR) – in the field of research paradigms and we differentiate DSR from design practice. In Sect. 3 we discuss the artifact types, i. e., the result types, of design-oriented business innovation research, and we specifically focus on design theory as the most comprehensive artifact type in Sect. 4. In Sect. 5 we discuss how to do design-oriented business innovation research, and we present three exemplars in Sect. 6. The article ends with a conclusion.

2 Positioning Design Science Research (DSR)

This section summarizes the positioning discussion from Winter's (2014a) paper on DSR in business research.

2.1 Is DSR always Action Research (and Vice Versa)?

Whereas explanatory research most often uses an "independent observer" perspective, DSR draws on a participant-observer perspective that requires knowledge on intervention-outcome-context combinations to be able to specify the (likely) outcomes of interventions in specific contexts (van Aken and Romme 2012, p. 145). Although Action Research (AR) generalizes a range of somewhat diverse approaches, they all combine theory generation with researcher intervention to solve organizational problems (Baskerville 1998, p. 91). As a consequence, DSR and AR share some characteristics so that Järvinen claims that these approaches are similar, if not identical (Järvinen 2007). Iivari and Venable however argue that (at least the canonical variant of) AR does not share the paradigmatic assumptions and the research interests of DSR (e. g., DSR assumes neither any specific client nor joint collaboration between researchers and the client) and that some activities in DSR are always mutually exclusive from AR (e g., understanding reality in context vs. devising generic solutions for a class of problems) so that DSR and AR are "decisively dissimilar" (Iivari and Venable 2009). Since DSR is a research orientation and AR a research method, however, combinations of DSR and AR might make sense. An example is provided by Sein et al. who propose to parallelize problem analysis and construction (DSR) with concurrent intervention and evaluation (AR) and "guided emergence" (reflection and learning) (Sein et al. 2011). For other purposes than the ones targeted by Sein et al., DSR can be combined with many other complementary research methods (e. g., case studies or experiments); Likewise, AR might be appropriate as a method in contexts other than design-oriented research (e. g., explanatory research).

2.2 Is DSR always Applied Research?

Another common misconception is that explanatory research is always "fundamental" (= not applied), while DSR is always applied (= not fundamental) – and, as a consequence, perceived to be less rigorous by some. Although fundamental, rigorous, applied, and relevant are important properties of research activities that are to some extent incompatible (Kieser and Leiner 2009), the ultimate goal of reaching the "Pasteur quadrant" of research (Stokes 1997) applies to research activities across all paradigms. Design should deliberately (re-)use relevant, applicable explanations and technologies – rather than being a purely pragmatic search (van Aken and Romme 2012, p. 153). DSR therefore is not just opportunistic solution search; it can and should instead be as rigorous as other forms of research.

This claim implies, however, that the outcome of DSR cannot be singular problem solutions. As Venable points out (Venable 2010, p. 1053), the difference between design practice and DSR is not in the idea of design, but the nature of the contribution: Ordinary problem solving (= design practice) is related to a particular, situated problem with particular stakeholders, and the resulting design is special purpose in nature, tuned to the particular situation. "Unlike in design practice, in DSR, the solution technology should be designed to address and solve not just one situation problem, but a type, kind, or class of problems. The solution technology developed should be relevant to typical classes of stakeholders who experience instances of the class of problem. Care should be paid to ensuring that the solution technology (type), once developed and disseminated for use, can be applied to solve a class of problems when or where they occur" (Venable 2010, p. 1051).

2.3 Two Worlds Apart or Complementary Paradigms?

Although business research was widely design-oriented for a long time, the last decades brought a dominance of explanatory research to many of its sub-disciplines. DSR is an important perspective for business innovation because it provides a critical component of the world – as long as (1) no tight prescriptions are proposed, but instead foundations for adaptation, extension, and instantiation, and (2) as long as design is 'evidence-based', i. e., that proposed solutions are grounded and generic. While explanatory research is needed to analyze and understand current and emerging business innovation phenomena, DSR is needed to make business innovation happen, i. e., to innovate and improve business practices. The paradigms are complementary rather than contradictory.

3 The Artifact View of Design-oriented Business Innovation Research

As a consequence of different approaches of theorizing, the knowledge base of business innovation research is comprised of artifacts that have either a descriptive character or a prescriptive character. As their name suggests, descriptive artifacts are used to represent statements about the object of analysis without any relations to goals or purpose. Their most important quality is hence 'truth'. Examples of descriptive artifacts are observations of empirical phenomena as well as principles, patterns, and theories that generalize these observations and can be designated as descriptive models.

In contrast, prescriptive artifacts are always related to some purpose or goal. Therefore, their most important quality is utility or 'value in context and use' rather than truth. A plethora of examples of such 'designed artifacts' in business research can be easily found in controlling (e. g., KPI systems), in accounting (e. g., calculation schemes, costing principles), in operations management (e. g., scheduling or inventory management methods, configurators), in educational research (e. g., interventions like teaching programs or materials), in organizational sciences (e. g., management principles, "technological rules"), in finance (e. g., pricing mechanisms), in information systems research (e. g., reference models, methods, information systems), etc.[2]

Extending March and Smith's taxonomy (March and Smith 1995, p. 255), Gregor and Hevner differentiate the following types of prescriptive artifacts (Gregor and Hevner 2013, p. A3):

- **Constructs** provide the vocabulary and symbols used to define and understand problems and solutions. Examples are the constructs of "entities" and "relationships" in the field of information modeling. The correct constructs have a significant impact on the way in which tasks and problems are conceived, and they enable the construction of models for the problem and solution domains.
- **(Problem or solution) Models** are designed representations of the problem class or of possible solutions. Examples are mathematical models or conceptual models (e. g., process models, information models) which are widely used in the information systems (IS) field.
- **Methods** are algorithms, practices, and recipes for performing a problem solution task. Methods provide the instructions for performing goal-driven activities. Examples are scheduling algorithms, service innovation methods, or teaching/learning methods.
- **Instantiations** are the physical realizations that act on the natural world, such as an IS that stores, retrieves, and analyzes customer relationship data, a project plan that

[2] Good overview texts are for example Geerts (2011) for accounting; Boland and Collopy (2004) for general management; Holmström et al. (2009) for operations management; Plomp (2007) for business education; van Aken 2004; Romme 2003 for organizational research; and Hevner et al. (2004) for information systems (IS) research.

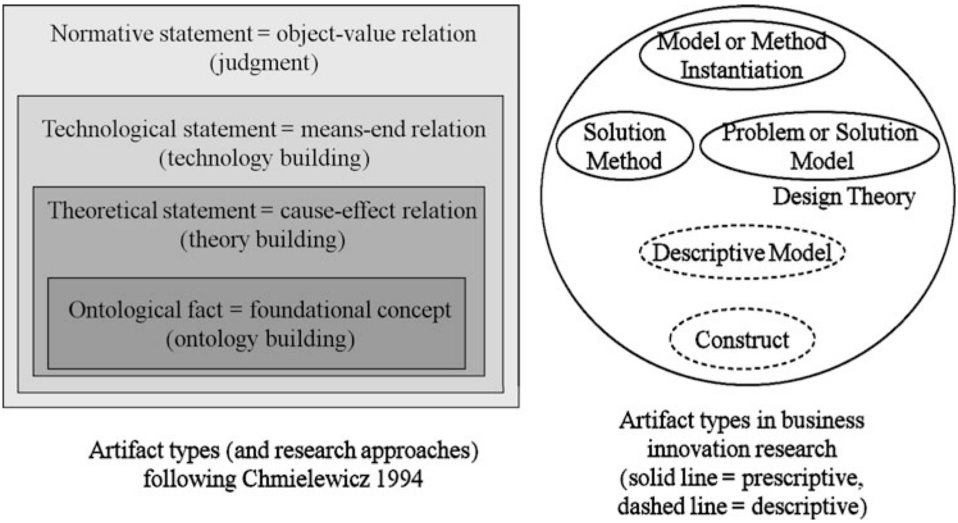

Fig. 1 Artifact types in business innovation research. (Adapted from Winter 2014b)

instantiates a service innovation method, or a course that actually implements some teaching/learning program.

- A **design theory**, which is an abstract, coherent body of prescriptive knowledge that describes the principles of form and function, methods, and justificatory theory that are used to develop an artifact or accomplish some end. Being a "theory for design and action", a design theory relates generalized solution components to generalized solution requirements of a problem class. It needs always to be justified by analytical, explanatory, and/or predictive knowledge. Examples are investment principles derived from portfolio theory that help to optimize the risk/return ratio or design guidelines for a class of IS derived from use analysis that help to maximize IS use.

It is important to understand the artifact types not as separate concepts, but as an interdependent system. Chmielewicz's (1994, p. 8) classification of research approaches in social sciences may serve as a foundation to explain such dependencies. He differentiates between four fundamentally different research approaches in social sciences which build upon one another: (1) ontology building, (2) theory building, (3) technology building and (4) judgment. The respective artifact types are (1) ontological facts (foundational concepts), (2) theoretical statements (cause-effect relations), (3) technological statements (means-end relations) and (4) normative statements (object-value relations).

Descriptive models (theoretical statements) use constructs (ontological facts) as their building blocks. Problem/solution models and solution methods (technological statements) should use theory as explanatory justification. Actual solutions (model or method instantiations) are instantiated from technologies based on specific choices (judg-ment). Figure 1 illustrates the relationships between Chmielewicz's classification (left)

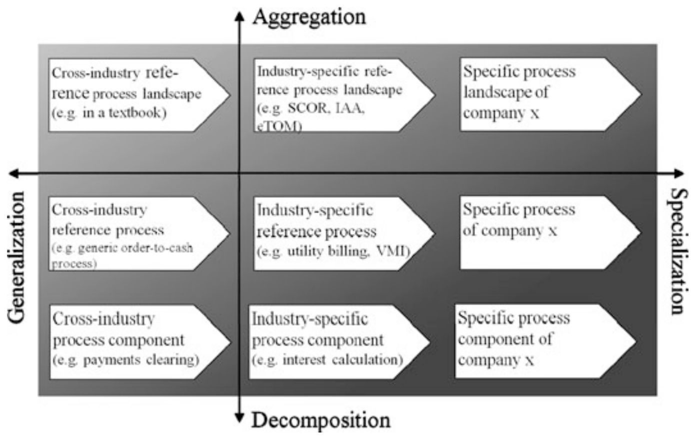

Fig. 2 Process Models on Different Abstraction Levels. (Winter 2014b)

and the system of descriptive and prescriptive artifacts in business innovation research (right).

In the light of the huge amounts of highly diverse artifacts in design research and design practice, the differentiation into descriptive and prescriptive artifacts, and in different artifact types is not sufficient for a precise analysis of research processes and outcomes. We propose to additionally differentiate artifacts on different levels of abstraction. While instantiations represent one situated artifact implementation in context and time (e. g., a specific project plan or a specific workflow instance or a specific algorithm at a certain point in time), all other artifact types such as solution methods, solution models, descriptive models, or constructs can be instantiated by a set of more or less complex artifacts that are linked to more or less diverse goals, subject to more or less diverse contexts, valid in more or less points in time, etc. In order to specify "more or less" abstraction, we propose to differentiate at least a generalization/specialization and an aggregation/decomposition sub-dimension: While the level of generality indicates how many different instantiations the artifact allows, the level of aggregation indicates into how many components the artifact can be decomposed. MIT's process compass illustrates that generalization/specialization and aggregation/decomposition are orthogonal sub-dimensions which specify the abstraction level of a process model (Malone et al. 1999, p. 428). Figure 2 illustrates the process compass idea. A lighter background color indicates more general and/or more aggregate process models. A darker background color indicates more specific and/or more decomposed process models. For various abstraction levels, exemplary processes are mentioned for illustration.

4 Design Theory – The "Holy Grail" of Design-oriented Business Innovation Research

As mentioned above, design-oriented theorizing in business innovation should ultimately yield a design theory. Such a process either is based on prior research that (a) defines appropriate constructs, (b) proposes and validates justificatory descriptive models, (c) constructs and evaluates problem and solution models as well as (d) solution methods, and maybe even (e) instantiates the design theory for validation purposes – or needs to comprise some or all of these steps in order to propose the design theory as an 'ensemble artifact'.

In its most simplified understanding, a design theory has been characterized by Venable as a utility theory: "a utility theory then links some solution technology concept or group of concepts to the aspect(s) of the problem(s) that it/they address. [...] Any utility theory proposed should be precise about what problem(s) it addresses, what way it addresses the problem(s) [...] and what benefit would occur from applying the solution technology" (Venable 2006, p. 185). This understanding is illustrated by Fig. 3.

Drawing on the 1992 Walls et al. paper (Walls et al. 1992) which dominated the design theory discussion for more than a decade, but suffered from unnecessary differentiations between design processes and products as well as from mixing up meta and generalization issues, Gregor and Jones proposed the following conceptual structure of a design theory that was widely adapted (Gregor and Jones 2007, p. 322):

Core components:

1. **Purpose and scope**: "what the system is for," the set of generalized requirements or goals that specifies the type of artifact to which the theory applies and in conjunction also defines the scope, or boundaries, of the theory.

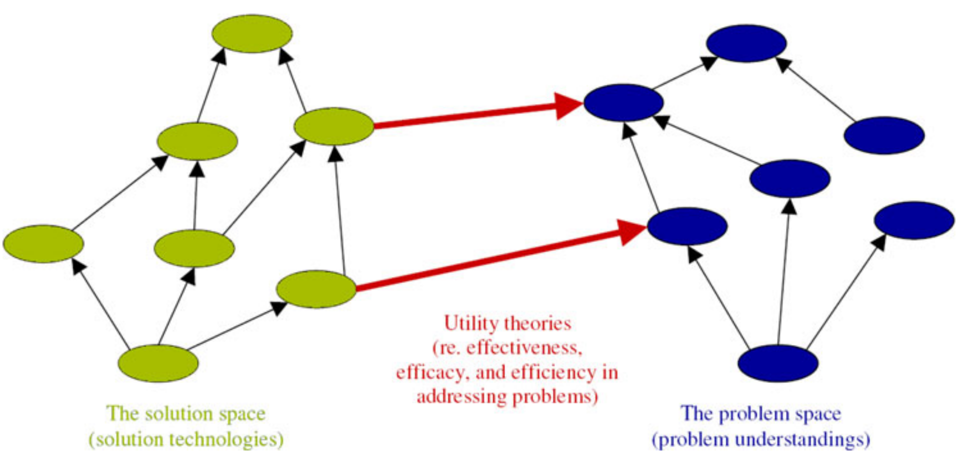

Fig. 3 Componential Structure of a Design Theory. (Venable 2006)

2. **Constructs**: representations of the entities of interest in the theory.
3. **Principles of form and function**: the abstract "blueprint" or architecture that describes an IS artifact, either product or method/intervention.
4. **Artifact mutability**: the changes in state of the artifact anticipated in the theory (i. e., what degree of artifact change is encompassed by the theory).
5. **Testable propositions**: truth statements about the design theory.
6. **Justificatory knowledge**: the underlying knowledge or theory from the natural or social or design sciences that gives a basis and explanation for the design.

Additional components:

7. **Principles of implementation**: A description of processes for implementing the theory (either product or method) in specific contexts.
8. **Expository instantiation**: A physical implementation of the artifact that can assist in representing the theory both as an expository device and for purposes of testing.

The important aspects of context and use are only indirectly (under "mutability") addressed by the Gregor and Jones "anatomy". Authors from the field of organizational sciences paid more attention to this issue from the beginning. Van Aken explicitly bases his concept of "technological rules" on DSR and Simon's work (van Aken 2004, 2005). Referring to Bunge who defined a means-end relation procedurally as "an instruction to perform a finite number of acts in a given order and with a given aim" (Bunge 1967, p. 132), in his early papers Van Aken adds an application context to the generic problem-solution relation first. Van Aken and Romme use the following example to illustrate the proposed link between a desired outcome, a generic problem-in-context and a generic intervention: "if you want to achieve a successful entry in a rather inaccessible foreign market by way of a cooperative arrangement with a local company, then use this particular type of contract." (van Aken and Romme 2012, p. 146) The most powerful technological rules are those, that are tested in their intended field of application and grounded in an understanding of the underlying generic mechanisms (i. e., cause-effect relations = explanatory theories) that produce the outcome (van Aken 2004, 2005). A few years later, Denyer, Tranfield, and van Aken (Denyer et al. 2008) further extend the concept of technological rules by differentiating context, intervention, mechanism, and outcome to what they designate as "CIMO" logic – an approach they also propose to organize the knowledge of a design-oriented discipline in a systematic and reusable way. Beyond covering all "anatomic" components according to Gregor and Jones (2007), a business innovation design theory should definitely address application/use contexts and valuation considerations in order to constitute a valuable contribution to the business innovation knowledge base.

5 The Process View of Design-oriented Business Innovation Research

There are a number of process models available that aim at guiding researchers in design-oriented business innovation research (Cole et al. 2005; Cooper et al. 2002a, 2002b; Cooper and Kleinschmidt 1993; Eekels and Roozenburg 1991; Hickey and Davis 2004; Rossi and Sein 2003). The work of Peffers et al. consolidates previous contributions and therefore became a prominent exemplar among these process models (Peffers et al. 2007).

Peffers et al. propose a process model that is comprised of six activities (Fig. 4) (Peffers et al. 2007, p. 54).

(1) Problem identification and motivation

In the first activity the addressed design problem needs to be identified and described. The problem description should provide sufficient detail and thus should be broken-down to sub-problems in order to later on develop solutions that correspond to the problem's complexity. An important aspect of the problem description is to discuss why this problem is worth being solved. The value of a possible solution needs to be justified. The understanding of the value of a possible solution often justifies the effort of the research process itself, it explicates the researcher's conception of the problem, and it is an important foundation for understanding and evaluating a possible solution.

In order to assess the value of a possible solution it is necessary for the researcher to understand the state of the problem, the respective application domain, and the maturity of existing solutions. Gregor and Hevner propose a 2×2 matrix to position the problem and the possible solution (Gregor and Hevner 2013, p. 344). They differentiate the four quadrants of improvement, invention, exaptation, and routine design (Fig. 5).

When business innovation research strives for *improvement* the application domain is usually well understood. However, solutions might not yet exist or existing solutions might have major deficiencies. Some of these deficiencies need to be addressed by the aspired solution. A large part of business innovation projects will strive for better solutions, i. e., more efficient and/or effective products, services, business processes, or business models.

On the opposite side of the matrix are existing solutions that are extended to fit new problems. Gregor and Hevner call these contributions *exaptations*. Exaptations often occur when general solutions, e. g., for data warehousing, are extended to new application domains, like the health care industry for example. It is important, however, that these new application domains present some particular challenges that have not yet been addressed.

Gregor and Hevner describe true *invention* as "a radical breakthrough – a clear departure from the accepted ways of thinking and doing. Inventions are rare and inventors are rarer still" (Gregor and Hevner 2013, p. 345). Inventions find new solutions to new problems that might not have been discussed before.

Finally situations where existing solutions are applied to known problems are considered routine design. Routine design hardly requires the application of research methods,

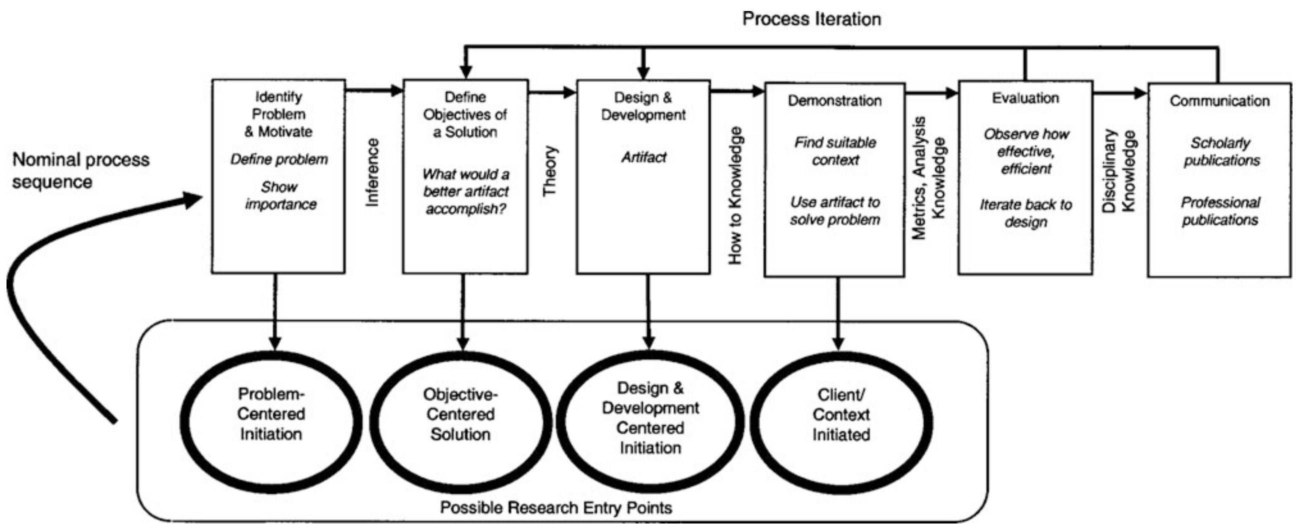

Fig. 4 Design Science Research Process Model. (Peffers et al. 2007)

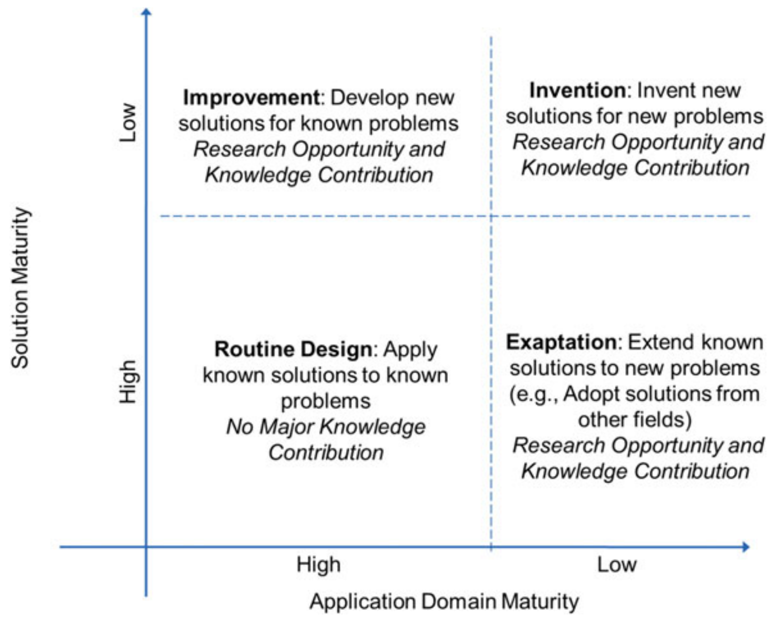

Fig. 5 DSR Knowledge Contribution Framework. (Gregor and Hevner 2013)

and contributions to research can therefore not be expected. Therefore, this quadrant is not discussed further.

In order to position the research within this framework it is necessary to analyze and understand prior work that is relevant to this research. The analysis should not be limited to theories and empirical research published in scholarly literature, but it additionally needs to cover the state-of-the-art in practice. The positioning of the problem and the possible solution within the aforementioned quadrants helps to focus on the relevant aspects in the following steps.

(2) Define the objectives for a solution

After the problem is described, the objectives for a solution, i. e., the solution's performance indicators, need to be inferred from the problem definition and knowledge of what is possible and feasible in the application domain. In improvement projects the objectives often can be quantitative, describing dimensions in which a possible solution would be better than current ones. In exaptation projects the objectives will often be qualitative, describing how the artifact is expected to address the specifics of the new application domain.

(3) Design and development

In the third step the actual artifacts are created. "Conceptually, a design research artifact can be any designed object in which a research contribution is embedded in the design" (Peffers et al. 2007, p. 55). Generally *inductive*, i. e., data-driven, and *abductive*, i. e., theory-driven, approaches can be distinguished (Simon 1987; Peirce 1958; Fischer et al. 2012). In inductive approaches artifacts are developed from observational data by inductive inference. Induction is important for building artifacts because it allows for generalizing singular observations (Wania and Atwood 2009, p. 2). As Gregor points out, generalization is an essential characteristic of any theory type (Gregor 2006, p. 616), and it thus is important for design-oriented business innovation research. Inductive artifact construction allows building on innovations in the real world without having to wait until such observations have been generalized by analytic, explanatory, and/or predictive theory that subsequently can be used to justify problem-oriented artifact construction.

Abductive approaches involve the creative use of background knowledge for discovering an innovative problem solution (Fischer et al. 2012, p. 3). Literature discusses role and forms of background knowledge under different terms. Walls et al. use the term *kernel theory* to refer to theory stemming from social or natural sciences that informs the artifact design (Walls et al. 1992, p. 41). Gregor and Jones use the term *justificatory knowledge* in a similar sense (Gregor and Jones 2007, p. 315). Hevner et al. refer to background knowledge in the form of a *knowledge base*, which is not only composed of explanatory theories, but also of other artifacts and their instantiations (Hevner et al. 2004, p. 80). While improvements and exaptations may result from inductive as well as from abductive approaches, inventions will most likely be the result of abduction as it emphasizes the role of creativity. The role of creativity, however, is relatively neglected at least in design-oriented IS research. Two exceptions to this observation are the contributions by Vaishnavi and Kuechler (2007) and by Gericke (2009). Both describe creativity patterns to develop new solutions. Like abduction, *deduction* involves theory as background-knowledge – but a discovery can never result from the pure application of deductive reasoning since it does not involve anything new (Toulmin 1958; Fischer et al. 2012, p. 3).

It is important to note that the design and development of artifacts often is an iterative process that is driven by feedback from subsequent activities of artifact demonstration and artifact evaluation. In their article on Action Design Research Sein et al. argue that the feedback not only from evaluating the artifact, but also from regularly applying it in its intended organizational context during design and development significantly shapes the design as well as the artifact (Sein et al. 2011, p. 38). They aim at integrating "the inseparable and inherently interwoven activities of building the [. . .] artifact, intervening in the organization, and evaluating it concurrently" (Sein et al. 2011, p. 37).

(4) Demonstration

The demonstration of the developed artifact aims at proving the artifact's validity. Validity means that the artifact works correctly and actually solves the addressed design problem. Peffers at al. mention experimentation, simulation, case study, or proof as exemplary activities to demonstrate the effectiveness of the solution (Peffers et al. 2007, p. 55).

(5) Evaluation

The purpose of the evaluation is to determine how well the artifact solves a problem (March and Smith 1995, p. 254). The evaluation needs to compare the achieved solution results to the solution objectives defined in activity 2. While evaluation is crucial for rigorous design-oriented business innovation research (Hevner et al. 2004, p. 82; Venable et al. 2012, p. 423; March and Smith 1995, p. 258), it often is difficult to achieve. Literature provides a number of aspects that should be considered in an evaluation (Hevner et al. 2004, p. 85; Aier and Fischer 2011). However, the aspect of *utility* of an artifact, which depends on the artifact's purpose and scope (Aier and Fischer 2011, p. 148), is central to most evaluation approaches.

In order to guide evaluation Venable at al. propose a framework for selecting an evaluation strategy (Fig. 6) and another framework for selecting one or several evaluation methods (Fig. 7) (Venable et al. 2012).

For using these two frameworks, Venable et al. propose a four-step process. In a first step, the researcher needs to analyze the requirements for the evaluation. In a second step, the researcher can map these requirements to one or more of the dimensions and quadrants in Fig. 6 and thus define an evaluation strategy. Based on the evaluation strategy, one or more appropriate evaluation methods can be selected using Fig. 7 in a third step. After these general considerations, the evaluation can be planned in detail in step four (Venable et al. 2012, p. 434):

1. Analyze the context of the evaluation – the evaluation requirements. As a first step, the researcher needs to identify, analyze and prioritize all of the requirements or goals for the evaluation.
   a) Determine what the artifacts to be evaluated are/will be. Will they be concepts, models, methods, instantiations, and/or design theories?
   b) Determine the nature of the artifacts to be evaluated. Are the artifacts to be produced a product, process, or both? Are the artifacts to be produced purely technical or socio-technical? Will they be safety critical or not?
   c) Determine what properties need to be evaluated. Which of these will be evaluated? Does the researcher need to evaluate utility/effectiveness, efficiency, efficacy, ethicality, or some other quality aspects?
   d) Determine the goal/purpose of the evaluation. Will the researcher evaluate a single/main artifact against the objectives? Does the researcher need to compare the developed artifacts with other, extant artifacts? Do the researcher need to evaluate the developed artifacts for side effects or undesired consequences (especially if safety critical)?
   e) Identify and analyze the constraints in the research environment. What resources are available – time, people, budget, research site, etc.? What resources are in short supply and must be used sparingly?
   f) Consider the required rigor of the evaluation. How rigorous must the evaluation be? Can it be just a preliminary evaluation or is detailed and rigorous evaluation

DSR Evaluation Strategy Selection Framework		Ex Ante	Ex Post
		•Formative •Lower build cost •Faster •Evaluate design, partial prototype, or full prototype •Less risk to participants (during evaluation) •Higher risk of false positive	•Summative •Higher build cost •Slower •Evaluate instantiation •Higher risk to participants (during evaluation) •Lower risk of false positive
Naturalistic	•Many diverse stakeholders •Substantial conflict •Socio-technical artifacts •Higher cost •Longer time - slower •Organizational access needed •Artifact effectiveness evaluation •Desired Rigor: "Proof of the Pudding" •Higher risk to participants •Lower risk of false positive – safety critical systems	•Real users, real problem, and somewhat unreal system •Low-medium cost •Medium speed •Low risk to participants •Higher risk of false positive	•Real users, real problem, and real system •Highest Cost •Highest risk to participants •Best evaluation of effectiveness •Identification of side effects •Lowest risk of false positive – safety critical systems
Artificial	•Few similar stakeholders •Little or no conflict •Purely technical artifacts •Lower cost •Less time - faster •Desired Rigor: Control of Variables •Artifact efficacy evaluation •Less risk during evaluation •Higher risk of false positive	•Unreal Users, Problem, and/or System •Lowest Cost •Fastest •Lowest risk to participants •Highest risk of false positive re. effectiveness	•Real system, unreal problem and possibly unreal users •Medium-high cost •Medium speed •Low-medium risk to participants

Fig. 6 Evaluation Strategy Selection Framework. (Venable et al. 2012, p. 431)

required? Can some parts of the evaluation be done following the conclusion of the project?

g) Prioritize the above contextual factors to determine which aspects are essential, more important, less important, nice to have, and irrelevant. This will help in addressing conflicts between different evaluation design goals.

2. Match the needed contextual factors (goals, artifact properties, etc.) of the evaluation (from previous step) to the criteria in Fig. 6, considering the criteria in the dimen-sions and in the quadrants. The criteria statements that match the contextual features of the business innovation project will determine which quadrant(s) applies(y) most or

DSR Evaluation Method Selection Framework	Ex Ante	Ex Post
Naturalistic	•Action Research •Focus Group	•Action Research •Case Study •Focus Group •Participant Observation •Ethnography •Phenomenology •Survey (qualitative or quantitative)
Artificial	•Mathematical or Logical Proof •Criteria-Based Evaluation •Lab Experiment •Computer Simulation	•Mathematical or Logical Proof •Lab Experiment •Role Playing Simulation •Computer Simulation •Field Experiment

Fig. 7 Evaluation Method Selection Framework. (Venable et al. 2012)

are most needed. It may well be that more than one quadrant applies, indicating the need for a hybrid evaluation design.

3. Select appropriate evaluation method(s) from those listed in the selected, corresponding quadrant(s) in Fig. 7. If more than one box is indicated, it may be helpful to select a method that is present in more than one box. The resulting selection of evaluation methods, together with the evaluation strategy, constitutes the high level design of the artifact evaluation.
4. Design the DSR evaluation in detail. Ex ante evaluation will precede ex post evaluation, but more than one evaluation may be performed and more than one method used, in which case the order of their use and how the different evaluations will fit together must be decided. Also, the specific detailed evaluations must be designed (e. g., surveys or experiments).

Depending on the evaluation results, researchers can iterate back to activities 2 or 3 or continue with the communication of the research results.

(6) Communication

In a final activity, the problem and the artifact that is proposed as a solution need to be *communicated* to relevant audiences such as researchers and practitioners. This communication should include the core considerations of the previous five activities, i. e., the importance of a solution for the respective problem, the artifacts' utility and novelty, the rigor of its design process, and the artifact's effectiveness. The presentation of the research in scholarly publications generally follows the common structure for empirical research papers adhering to respective disciplinary cultures. Still, researchers often struggle to present their designs, which is why Gregor and Hevner provide some concrete guidance on how to structure a design-oriented research paper (Gregor and Hevner 2013, p. 349):

1. *Introduction section*: In the first section the problem has to be defined and its significance needs to be motivated, key concepts need to be introduced, the research questions have to be stated and the objectives should be linked to the respective artifact. Furthermore the scope of study, the overview of methods and findings, their theoretical and practical significance should be outlined. The introduction finishes with the presentation of the structure of the remainder of the paper.
2. A *literature review section* should present prior work that is relevant to the research, including theories, empirical research, and reports from practice. Specifically the literature review should include any prior design theory/artifacts relating to the class of problems to be addressed.
3. *Method section:* The specific design research approach adopted should be explained with reference to existing authorities. It should be linked to the type of problem, the application domain, and the maturity of possible solution components.
4. *Artifact description section*: The artifact needs to be concisely described at the appropriate level of abstraction to make a new contribution to the existing knowledge. This should occupy the major part of the paper. The format depends on the artifact and its positioning but should include the description of the designed artifact and the design process.
5. The *evaluation section* gives evidence that the artifact is useful. The artifact is evaluated to demonstrate its value addressing criteria such as validity, utility, and, perhaps, others related to the design objectives.
6. The *discussion section* interprets the results, what they mean, and how they relate back to the design objectives. The discussion should include a summary of what was learned, the progress over prior work, the research's limitations, its implications for research and practice, and its fruitfulness for further research.
7. The *conclusion section* restates the important findings of the work, the main ideas in the contribution, and why they are important.

6 Exemplars of Design-oriented Business Innovation Research

In this section we present three examples for design-oriented business innovation research. We present activity based costing (ABC) as an exemplar of improvement, data mining association rules as an exemplar of invention, and a method for setup time reduction for electronics assembly as an exemplar of exaptation.

6.1 Activity Based Costing

Activity based costing (ABC) is a costing method that assigns an organization's resource costs to its products and services. This cost assignment is the foundation for various management decisions like decisions on pricing, selections in a product portfolio, or possible changes of production processes. In order to take decisions like these based on appropriate information, it is necessary to assign as much of the indirect cost to the respective products or services as possible.

Traditional costing approaches assign direct labor and material costs straight to a product or service and use overhead rates to assign indirect costs (for machines and support operations like marketing, distribution, engineering, and other overhead functions). However, as the percentage of direct costs decreased and indirect costs rose due to the replacement of manual labor by automated machines, the cost assignments in multi-product organizations became increasingly inaccurate. The inevitable results were inappropriate management decisions based on inappropriate data in organizations that often had growing product portfolios.

The two major proponents of ABC, Cooper and Kaplan, therefore proposed to identify cost-driving activities in an organization and to assign direct as well as indirect costs to a product or service based on its actual consumption of resources (Cooper and Kaplan 1988). As a result, a higher percentage of the overall costs for resources can be turned into direct costs compared to conventional costing.

ABC is an example of an improvement based on inductive reasoning because ABC improves the accuracy of existing cost accounting approaches based on several empirical observations of specific solution components (March and Kaplan 1987; Cooper et al. 1985). Although Cooper and Kaplan made ABC widely known in academia and practice, it has some theoretical predecessor in the work of Staubus (1971). However, it is unclear in how far Staubus' work provided the actual theoretical foundation for Cooper and Kaplan's work (Jones and Dugdale 2002, p. 134). The development is also an example of focusing on the relevance of a problem and its solution's practical impact in its organizational context (Kaplan 1986, 1988). ABC has been demonstrated and evaluated not only by Cooper and Kaplan, but also by a number of other authors over the years focusing on different aspects like the improvement of management decisions, the effort of implementing ABC, or on ABC's adoption in practice.

6.2 Mining Association Rules between Sets of Items in Large Databases

A good example for invention is the contribution by Agrawal et al. (1993) who propose an algorithm that generates all significant association rules between items in large databases. This paper has generated and influenced a whole new field of research (Gregor and Hevner 2013, p. 346).

The authors address "typical business decisions that the management of the supermarket has to make including what to put on sale, how to design coupons, how to place merchandise on shelves in order to maximize the profit etc." (Agrawal et al. 1993, p. 1). Typically transaction data has been used to improve the quality of such decisions. However, before the invention "only global data about the cumulative sales during some time period (a day, a week, a month etc.) was available on the computer. Progress in bar-code technology has made it possible to store the so-called basket data that stores items purchased on a per-transaction basis. Basket data type transactions do not necessarily consist of items bought together at the same point of time. It may consist of items bought by a customer over a period of time" (Agrawal et al. 1993, p. 1), e. g., by members of a book club or a music club. "An example of such an association rule is the statement that 90 percent of transactions that purchase bread and butter also purchase milk" (Agrawal et al. 1993, p. 1).

The authors present a "*method* for extracting the association rules, including the novel *constructs* of a confidence level (what percentage of transactions containing one part of the rule also contain the other part) and rule support (the percentage of transactions in the database satisfying the rule)" (Gregor and Hevner 2013, p. 340). This research also is an example for abductive reasoning. Although existing theory, i. e., existing algorithms and mathematical laws, are used, it is a creative task to (1) formulate the respective problem and (2) build a solution that later proved to be very influential.

For purposes of demonstration and evaluation, the authors implement their proposed algorithm in a software solution and test it with data from a large, real-life database. They specifically evaluate the effectiveness of their solution. What is missing though is an explanation of why and under which specific conditions the method works as it does. However, subsequent research filled this gap and also transferred the novel approach to other application domains such as web usage mining, business intelligence, and security breach detection (Gregor and Hevner 2013, p. 340).

6.3 Applying Methods of Setup Time Reduction From One Context of Application to Another

The work by Trovinger and Bohn examines setup time reduction for printed circuit board assembly (PCBA) in the electronics industry (Trovinger and Bohn 2005). PCBAs are found in virtually every electrical product and form their basic building blocks. Setup processes are vital because they have major impacts on downtime, capacity, quality, and costs. Trovinger and Bohn's work is an example for an exaptation since it uses the classic, common sense *Single Minute Exchange of Dies* (SMED) approach that was first developed for metal fabrication processes (Shingo 1985). However, Trovinger and Bohn additionally develop a factory information system, with hand-held wireless barcode computers, to further reduce setup times and increase setup accuracy specific to the printed circuit board assembly in the electronics industry. This example also employs abductive reasoning since it employs existing theory and creatively extends it to new application domains.

What stands out in this paper, as an example for design-oriented business innovation research, is the solution's demonstration and in particular its evaluation addressing different aspects such as reduction of setup times, the added economic value of faster setups, the total savings, other benefits, and the development costs and issues. For a specific case the authors measure a reduction of key setup times by more than 80 % and direct benefits of $1.8 million per year with a total cost of the changes being approximately only $350,000.

7 Conclusion

In the article at hand we advocate the opportunities that design-oriented business innovation research offers to researchers and to practice. Beyond research that aims at understanding phenomena of business innovation that already exist and can be observed, design-oriented research can contribute to changing the world into a better or preferred one. However, it requires (1) a rigorous application of a sound methodology, as any other research does, and (2) it should build on appropriate explanatory and/or predictive theory.

As Gregor and Hevner state, design-oriented research suffers from ongoing confusion and misunderstandings of its central ideas, positioning, and goals (Gregor and Hevner 2013, p. 338). Therefore the paper at hand provides an overview on the relations of design-oriented business innovation research to other research paradigms in business research, and it summarizes and links to state-of-the-art guidance for conducting design-oriented business innovation research. There are two points we want to highlight in particular. This is first, the role of practice, and it is second, the role of theory.

When we aim at building solutions for relevant problems, we think it is valuable to not only conduct research on problems in practice, but to conduct it together with practice. A significant part of the artifacts we contribute are supposed to work in complex organizational settings. An effective research approach would need to capture this complexity (e. g., Kaplan 1986). We consider it valuable for the researcher to actually *experience* the organizational settings they build artifacts for. This may contribute to the design and the design process, and it may even contribute to identify and describe the possibly latent problem(s). There are a number of approaches on how to incorporate practice in design-oriented business innovation research. We want to mention two of these briefly: (a) Action Design Research as proposed by Sein et al. (2011) and (b) Consortium Research as described by Österle and Otto (2010). Action Design Research provides immediate feedback on how a complex organizational setting influences the performance of an artifact. The concept of the 'organizational shaping' of an artifact is unique, and can hardly be achieved disconnected from practice. Consortium Research supports the researcher through the whole research process from describing the problem, through designing the artifact, to evaluating and finally disseminating the solution. This is significant given the fact that (1) business innovation largely takes place in the practitioner community and that

(2) companies often allocate resources for business innovation that are much larger than the resources available in academia (Österle and Otto 2010, p. 283).

However, design-oriented business innovation research must not be confused with routine design or even consulting. Beyond the differences discussed in this paper, we want to stress the role of explanatory and/or predictive theory. Citing Lewin, "there is nothing more practical than a good theory" (Lewin 1952, p. 169). The more we understand the complex organizational settings, the more explanatory theory will help to focus the actual problem, and the more explanatory theory will guide us in building effective solutions. This requires, however, a solid understanding of a broad range of existing (explanatory and/or predictive) theory and sometimes even contributions (like extensions, specializations) to explanatory and/or predictive theory. Both requirements require an appropriate academic education in both traditional, behavioral research, and design-oriented business innovation research.

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