Towards an understanding of the Role of Design Thinking for Requirements Elicitation – Findings from a Multiple-Case Study.

Completed Research

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Abstract

Effective requirements elicitation is perceived to be one of the most crucial activities in software-intensive development projects. While many scholars and practitioners have pointed out and agreed upon its numerous challenges, others consider the increasingly popular approach of Design Thinking to be the promising 'cure.' This paper provides robust empirical evidence of the role of Design Thinking for requirements elicitation and to help overcome its challenges. Specifically, this paper presents learnings in terms of *process guidance*, *stakeholder communication*, and *requirements quality* based on insights from a multiple-case study. In sum, Design Thinking introduces new structures and methods to enhance elicitation efforts and inspires a mind-shift towards a more human-centered and creative way of requirements elicitation. This work provides a better understanding of the multi-faceted potential of Design Thinking for requirements elicitation for both, scholars and practitioners.

Keywords

Design Thinking, requirements elicitation, systems analysis, multiple-case study.

Introduction

It is widely acknowledged that the design of a successful information system (IS) anchors in a thorough understanding of the real-world problem, in which the system will ultimately reside (Maguire and Bevan 2002). Solely a profound apprehension of user needs and requirements will result in a desirable solution with features that satisfy customers and users alike. Effective requirements elicitation, which is the process to discover those needs, is generally perceived to be one of the most crucial activities in software-intensive development projects (Hickey and Davis 2004). The higher the quality of elicited requirements, the easier it is to implement them in the state of the intended purpose. However, "getting the requirements right" is a complex endeavor. Previous research has revealed multiple challenges in requirements elicitation such as a frequent disregard of actual user needs, communication issues, or a lack of creativity (Inayat et al. 2015; Méndez Fernández and Wagner 2014). Thus, the requirements engineering community calls for research on improving requirements elicitation as this holds much promise for enhancing the success of software systems (Hickey and Davis 2004).

Design Thinking can be considered a "modern form of requirements engineering" (Beyhl and Giese 2016, p. 288). It has become an increasingly popular problem-solving approach to create innovative and human-centered solutions in the early stages of (new) product, service, and system development process, when the real-world problem is 'wicked', i.e., very complex (Buchanan 1992; Kolko 2015). Rather than focusing on technology solutions prematurely, Design Thinking leverages a toolset of ethnographic and human-centered methods to delve deeply into problem analysis. Applying rapid (non-technical) prototyping and iterative testing cycles, not only helps to define the purpose of an IS, but also its general shape. This rather

diverging approach to problem-solving is significantly different from the more converging approaches of elicitation practices in most software-intensive projects (Harte et al. 2017).

Our research interest arises from the demand for more effective requirements elicitation and the perception of Design Thinking as a promising 'cure'. Prior literature has recognized the importance of human-centered approaches in terms of product quality, process speed, and user acceptance (e.g., Rouse 2007) and hinted on the value of Design Thinking for eliciting requirements in software-intensive projects (e.g., Harte et al. 2017). However, while requirements elicitation is able to look back on a longer tradition in research and practice, there is only limited knowledge about Design Thinking, as Yoo (2017, p. v) underpins in his call to "advance the intellectual foundation of Design Thinking" for IS research. Particularly little is known about the specific impact on requirements elicitation. A more profound understanding of Design Thinking would enable both communities (requirements engineering and Design Thinking) to better evaluate its application purpose and potential for eliciting requirements. Accordingly, we propose the following research question:

RQ: What can be learned from Design Thinking for requirements elicitation in software-intensive projects?

To investigate our research question, we set up an exploratory multiple-case study, based on twelve cases from three consecutive years in multiple problem domains. We use existing theoretical and empirical knowledge about the challenges of requirements elicitation as a lens to analyze the contribution of Design Thinking. We provide scholars and practitioners a set of learnings for requirements elicitation in the dimensions of *process guidance*, *stakeholder communication*, and *requirements quality*. We argue that many Design Thinking methods are similar, yet different enough to enrich and complement current elicitation practices with a guiding process, a strong focus on users and their needs, and techniques that foster the generation of innovative outputs. Our research findings not only contribute to extending the understanding of Design Thinking and its value for requirements elicitation, but also provide insights for professionals in the quest of making optimal decisions in and for the development of software-intensive systems.

The remainder of the paper is organized as follows. First, we establish the research background of the study by drawing on literature about requirements elicitation and Design Thinking for IS. Second, we describe our research approach, data sources, collection, and analysis. Third, we describe the findings and evaluate them in the context of known requirements elicitation challenges. Finally, we discuss our learnings and conclude by suggesting an agenda for further research.

Research Background

Challenges in requirements elicitation

Requirements elicitation represents an early but continuous activity to determine the needs and requirements of all relevant stakeholders (Hadar et al. 2014). In order to define the features of a software system, there is a common understanding to look at requirements from three perspectives: (1) why a system is needed (context analysis), (2) what system features will serve to satisfy this context (functional requirements), and (3) how the system is to be constructed (non-functional requirements including system qualities such as security, safety, performance, usability, customizability etc. and constraints such as legal, physical, environmental constraints etc.) (Chung and do Prado Leite 2009). The description of tasks performed in requirements elicitation varies, but they can be broadly categorized into (1) understanding the domain, (2) identifying relevant sources, (3) analyzing stakeholders, (4) selecting techniques, and (5) obtaining the requirements. In reality, this is a complex and iterative endeavor that heavily relies on the communication skills of the analyst, involving many activities, with multiple techniques at hand to perform these activities (Zowghi and Coulin 2005).

Academics have generated long lists of challenges in requirements elicitation. Based on a structured literature review (Webster and Watson 2002), we have summarized the main challenges of requirements elicitation practices in terms of *process guidance*, *stakeholder communication*, and *requirements quality*. The results of our analysis are presented in Table 1.

#	Challenges	Explanation	Key Literature
Process Guidance (Process)			
C1	Lack of process guidance	There is little guidance on selecting the "right" method in different contextual situations. Many techniques developed in theory are not considered sufficiently useful for practice.	Carrizo et al. 2014;
C2	Lack of creativity	The process of eliciting requirements is missing creativity and the application of creativity techniques to develop innovative software systems.	Mich et al. 2005; Maiden et al. 2004
C3	Insufficient technical translation of needs	Many terms used in the real world are hard to translate into exact technical specifications (e.g. 'user friendliness') and are, thus, easily misinterpreted or prone to 'wrong' execution.	Davey & Parker 2015
Stakeholder Cognition and Communication (Cognition)			
C4	Communication gaps with stakeholders	Stakeholders can encounter difficulties articulating their needs or requirements, e.g. due to cultural differences or a lack of common language between analyst and stakeholder.	Davey & Parker 2015
C5	Tacit knowledge is hard to grasp	Stakeholders cannot express their needs or requirements clearly because they have only tacit knowledge about them and the topic.	Zowghi & Coulin 2005
C6	Analyst has limited knowledge/capability	Analysts are not equipped with sufficient expertise (e.g., wrong choice of techniques) or capability (e.g., lack in soft skills) to perform effective requirements elicitation.	Hadar et al. 2014; Davey & Parker 2015
Quality of Requirements (Quality)			
C7	Requirements are invented, not elicited	Requirements don't anchor in 'discovered' needs but rather are invented by analysts or developers.	Karlsson et al. 2007
C8	Requirements volatility	Requirements change over time due to multiple reasons, e.g. new market trends, feedback from coding reviews, resource constraints, or the influence of new business requirements.	Karlsson et al. 2002; Davey & Parker 2015
C9	Lack of traceability and interdependency	Requirements are not traceable, especially in complex project environments, and/or their (dynamic) interdependencies are hard to deal with.	Karlsson et al. 2007
C10	Incorrect, incomplete, and inconsistent requirements	The set of elicited requirements may lack in the "three Cs": correctness, completeness, and/or consistency.	Zowghi and Coulin 2005

Table 1. Challenges of Requirements Elicitation

Design Thinking as a promising way to overcome these challenges

Prior literature has acknowledged the value of Design Thinking for eliciting requirements in software-intensive projects (e.g., Harte et al. 2017). The roots of Design Thinking, however, originate from design research by taking a fresh perspective on design beyond aesthetics (Simon 1996). To that effect, the logic and intellectual activity behind Design Thinking is substantiated in "the way designers think" (Dunne & Martin 2006, p. 517) and applied to other disciplines to address complex problems of any kind (Brown 2008). Approaching problems with Design Thinking is, thus, about fully understanding the problem prior to deliberating possible solutions or predetermined results. Hence, in Design Thinking, the actual problem analysis is subject to at least as much (or more) attention as to finding and developing ideas.

Research has investigated three perspectives on Design Thinking: (1) as a process that people should stick to, (2) as a toolbox model with a loose bundle of methods for adaptive support, and (3) as a mindset that should be internalized (Brenner et al. 2014). All three views are strongly interrelated, however, have different conceptualizations on a practical level. In this study, we mainly focus on Design Thinking as process, however, we kept the other dimensions in mind when interpreting our results. For our study, we draw on a normative model, which was adapted from a Design Thinking course at Stanford University. In this context, Design Thinking is seen as a combination of a micro- and macro-process with the micro-process embedded into the macro-process. The former suggests two exploration stages: the exploration of the problem domain (including (1) Problem (Re-)Definition, (2) Needfinding, (3) Synthesis) and the exploration of the solution domain (including (4) Ideate, (5) Prototype, (6) Test), both consisting of an interaction between information gathering (divergent activities) and information processing (convergent activities). The exploration of the problem domain requires, firstly, broadening the view of the problem by considering all the relevant stakeholders, needs, and their context, and, secondly, re-framing and synthesizing the findings to a clearly defined point of view. The exploration of the solution space expands the scope again by generating many ideas so as to condense them into tangible prototypes and evaluate them by testing in the next step. This process is repeated in each phase of the macro-process, which covers a substantial pre-research phase (Design Space Exploration) and six prototyping phases, that converge to one final solution. During this process, iterations are carried out whenever and wherever necessary as they are essential to adapt to new information and gain deeper insights.

Research Methodology

We chose an exploratory study design since our research examines the learning potential of Design Thinking for eliciting requirements. As we aimed to generate generalizable and robust findings, we selected cases that were mainly replications of each other, which is why a multiple-case study approach seemed most appropriate (Yin 2011).

Case selection

The unit of analysis focuses on project teams and the artefacts they produce by applying Design Thinking. Each team approaches a problem statement from a corporate sponsor guided by the Design Thinking process in a university-setup as introduced in the research background. We selected twelve cases following the principles of similarity and variation (Eisenhardt 1989). We aimed at similarity in terms of project duration (8 months), an IS-related problem statement, a multi-disciplinary team configuration (mainly master students from business, design, informatics, and engineering), and the knowledge level of Design Thinking. The team members had no or little prior experience in using the presented design thinking approach for requirements elicitation. However, they shared the same level of coaching support from experienced Design Thinking experts to elicit needs and requirements to address their problem statement. All cases were equipped with the same (or a similar) data base, i.e., sources of evidence for our data analysis. Our selection explicitly sought variation in other characteristics such as the corporate sponsor's specific problem statement, their industry, and firm structure. Because the intent of this study is to generate a holistic view on requirements elicitation in Design Thinking projects, variation in context was especially desirable. By balancing the principles of similarity and variation, we identified twelve projects from nine organizations in three consecutive years as appropriate cases (Table 2).

Case	Company Name	Country	Industry Sector	Revenue '16 (B. EUR)	# of employees	# of prototypes; type of final solution	Team Size	Year
A	Alpha	Germany	Pharma	ca. 15	ca. 50'000	33; Chatbot	6	15/16
B	Beta	France	Pharma	ca. 15	ca. 110'000	32; Smartwatch App, CRM Plug-in	3	15/16
C	Gamma	Germany	Pharma	ca. 15	ca. 48'000	32; Platform, App, hardware device	7	15/16
D	Delta	Germany	Financial	ca. 33	ca.142'000	28; App	3	15/16
E	Epsilon	Germany	Conglomerate	ca. 39	ca. 155.000	44; Platform	8	14/15
F	Zeta	Germany	Information	ca. .06	ca. 500	44; App	7	14/15
G	Eta	Germany	Aviation	ca. 5	ca. 21'000	36; Platform	4	14/15
H	Theta	Switzerland	Financial	ca. 40	ca. 53'000	23; App	7	14/15
I	Theta	Switzerland	Financial	ca. 40	ca. 53'000	33; Platform	8	13/14
J	Iota	Germany	Automotive	ca. 58	ca. 84'000	46; Web App	4	13/14
K	Alpha	Germany	Pharma	ca. 15	ca. 50'000	55; Platform, Smartwatch App	8	13/14
L	Zeta	Germany	Information	ca. .06	ca. 500	52; Platform	8	13/14

Table 2. Case Details

Data collection

The authors of this paper were lecturers in the course with numerous years of experience in applying Design Thinking in corporate settings. The data was collected from October 2013 until June 2016 via multiple sources of evidence (SoE) for the purpose of data triangulation, construct validity, and reliability (Yin 2011). We compiled project documentations (SoE1), physical artifacts (SoE2), and participant-observations (SoE3) for each case. First, project documentations include (a) two text documentations about intermediate results and the final prototype (35-140 pages), (b) a booklet showcasing all produced prototypes and corresponding testing feedback (20-50), (c) a video about the final prototype, and (d) pictures of intermediate work results (ca. 300). We gathered SoE1 because our topic is concerned with requirements elicitation in Design Thinking projects and, thus, we see all documentation generated within the project as an indicator for analyzing our research questions, mainly on a content-basis. Second, we gathered all physical and digital artefacts, i.e., prototypes ranging from low to high resolution (32-52). In Design Thinking, elicited needs and requirements are expressed via prototypes, which appoints them a vital role within our research evaluation. Third, participant-observations include (a) memos of weekly review meetings (28), (b) lecture materials (32), and (c) team performance reports at certain project milestones (6). We collected SoE3 to gain process-oriented insights about applying Design Thinking for requirements elicitation.

Data analysis

We applied a team-based research approach and used cross-case analysis as the study's analysis strategy (Yin 2011). All researchers were experienced Design Thinking or Requirements Engineering practitioners as well as trained academics. First, we analyzed all cases separately in reference to the dimensions of Table 1, always keeping an open mind to extend the lens of these challenges (Stake 2005). Specifically, we coded relevant passages and derived themes for requirements elicitation. Each document was independently analyzed by two researchers to avoid subjective interpretation and enhance validity of our study (Yin 2011). To demonstrate rigor, two researchers discussed the results and revised the themes together in an iterative approach. For example, we particularly identified themes that addressed *user requirements* (e.g., "the solution must evoke positive emotions during usage", or "the bot should be usable by voice recognition") or *usability requirements* (e.g., "the bot should be easy to setup and use"). As a result of the first analysis round, we assigned a conceptual label to each theme (e.g. "user requirements", "usability requirements", "context analysis"). Second, we linked similar themes together into categories (Stake 2005). Thus, we merged *workflow requirements*, *user requirements*, and, *usability requirements* into the category "user requirements" and cross-referenced it with the identified elicitation challenges. Third, we used cross-case analysis to derive the core learnings of our study. In this phase, a third researcher acted as a sparring partner to shape the final set of learnings and to provide quality assurance and objectivity. This also increased the internal validity of our research (Eisenhardt 1989).

Research Results

We identified 7 key learnings from the use of Design Thinking for requirements elicitation; each learning is associated with one of the challenge dimensions *process guidance (process)*, *stakeholder communication (cognition)*, and *requirements quality (quality)*. Table 3 highlights which learning supports which elicitation challenge(s) (grey-shaded). It also provides an evaluation to what extent we perceive Design Thinking to support each challenge based on the results of the cross-case analysis and our experience. A high learning potential is marked by (++), inversely, (--) indicates that Design Thinking is not perceived helpful or suffers similar challenges.

#	Learnings derived from case studies	Case	Elicitation Challenges									
			Process			Cognition			Quality			
			1	2	3	4	5	6	7	8	9	10
L1	Design Thinking provides a guideline for requirements elicitation.	all	x	x	x	x	x	x	x	x		x
L2	Design Thinking explicitly differentiates between user needs and requirements.	all	x	x	x				x			
L3	Design Thinking enhances creativity by creating re-framed system contexts in problem- and solution domain.	B, C, D, E, I, K	x	x	x	x			x			x
L4	Design Thinking leverages prototyping as a major method to elicit functional and non-functional requirements, already in early project phases.	all		x	x	x	x	x		x		x
L5	Design Thinking enhances the priority of eliciting non-functional requirements with a special focus on user experience.	all			x	x			x	x		x
L6	In Design Thinking, context is about the human, not the system.	all		x	x	x	x		x	x		x
L7	Design Thinking takes a holistic view on requirements elicitation for a domain-agnostic solution.	A-D, G, I, K, L		x			x		x	x		x
Impact on individual Requirements Elicitation Challenges			++	++	++	+	++	+	++	+	--	+

Table 3. Research findings

We especially see high learning potential for *process guidance* and *stakeholder communication*. A rather mixed evaluation needs to be stated for dealing with challenges in the dimension *quality of requirements*. In general, we could hardly find supporting evidence to suggest positive impact on Challenge 9 (traceability). Similar to existing requirements elicitation techniques, we found that needs and requirements discovered in Design Thinking projects lack traceability, despite the process-oriented way of approaching problems. Our memos highlight the confusion of teams when attempting to recap previous insights and requirements: "*Where did we document it? Did we document it all? How did we get there*?

(Case E)." We explain this finding with the working attitude of Design Thinking teams, that, similar to agile techniques, prioritizes doing over documenting to quickly move forward. In that sense, we do believe that Design Thinking can learn from the more formalized way of documenting in requirements elicitation.

Learnings regarding elicitation process and methodological challenges

Learning 1 – Design Thinking provides a guideline for requirements elicitation. All project teams in our study followed the iterative problem-solving approach of the micro- and macro-process as described in Section 2. While leaving enough freedom on the use of specific methods, the structure helps to systematically focus on user needs first and only then turn them into testable solutions. A statement of one project member highlights the usefulness: "*Design Thinking provides us with a helping guideline on what to do next, without forcing us to apply a technique that we didn't find useful*" (Case K), and another one adds *"it is extremely helpful to have a framework that steers you, but that does not overpower you. It encourages to think about content, not the process"* (Case H). We find that the structured, yet flexible process framework of Design Thinking could help to overcome the often-mentioned lack of guidance in conducting requirements elicitation (C1). We firmly believe, that integrating process steps of the Design Thinking micro- and macro-model into existing practices will lead to a more effective requirements elicitation. A structure will help the novice to more confidently approach unknown situations and the expert to oversee complex problems more easily. We find that, at least in part, this also helps balance capability and experience issues of requirements analysts. In addition, we see the application of a guiding, yet not rigid framework for requirements elicitation positively influencing most of the other challenges as well. For example, the Design Thinking process has institutionalized the application of creativity techniques (C2) and a structured translation from needs into requirements (C3). Furthermore, with every iteration of the Design Thinking process, the team gains deeper knowledge of the problem domain and empathy with the stakeholders and, thus, collects more detailed needs and requirements leading to further adjustments in order to mitigate the risk of not addressing user needs in the long run (C7,10).

Learning 2 – Design Thinking explicitly differentiates between user needs and requirements. In Design Thinking, an explicit distinction is drawn between discovering needs and deriving requirements. User needs relate to people and express their wants, beliefs, and desires. Requirements are expressions of what is demanded to fulfill these needs with an intended solution. Thus, requirements provide an answer, or at least the direction towards an answer, for meeting the elicited user need. On a process level, this is defined by the interplay of needfinding, which focuses on the human (need-driven), and ideation and prototyping, which concentrates on finding a solution (requirement-driven). Several project teams applied methods like Maslow's need hierarchy or the "Common-to-Qualifier-Framework" to structure needs and derive requirements accordingly (Cases K, H, I). In Case A, for example, the team identified the following need: "*Multiple Sclerosis (MS) patients have a great need for an understandable, suitable, and accessible source of MS information*." Based on this need, the team translated and derived several requirements like "*The solution must be available in the user's native language,*" or "*Sent content must reach the user in nearly real-time*". Putting our results into the context of established elicitation practices, we see, that Design Thinking provides a set of activities and methods to foster the translation of elicited needs into requirements (C3) and to prevent the invention of new requirements (C7) due to establishing an explicit, logical connection between needs and requirements.

Learning 3 – Design Thinking enhances creativity by creating re-framed system contexts in problem- and solution domain. Design Thinking has institutionalized the framing and re-framing of given problems to challenge stereotypical perceptions, encourage learning, and enhance creativity. Case D, for example, visualized their discarded prototypes from early elicitation phases to make failures and learnings explicit and, thus, to inspire continuous experimentation and re-framing. Another team re-framed their given problem statement of "How does an intelligent collaboration platform in the engineering process for our engineers look like?" into the vision *"We aim to coordinate knowledge and information in order to enable transparent communication for engineers"* based on their learnings from needfinding and testing (Case E). Eventually, the final prototype looked vastly different from the originally intended platform idea of the project sponsors as the team had created an email-embedded software prototype for knowledge management. During testing, users highlighted the ease of use, as well as the integration and usefulness in their day-to-day business. Our research suggests learning potential for requirements elicitation practices as it mainly addresses process-and method-related (C1-3) and quality challenges (C7, 8, 10). The process of re-framing problems in Design Thinking might contrast the more rational analytic approach prevalent in

most elicitation practices. From our point of view, requirements elicitation should be viewed as an explorative dialog with stakeholders and users to obtain questions first to find better answers eventually.

Learning regarding Cognition and Communication

Learning 4 – Design Thinking leverages prototyping as a major method to elicit functional and non-functional requirements, already in early project phases. The usage of (non-technical) prototypes to gain early user feedback is a key component of Design Thinking. Prototypes are utilized to pursue multiple objectives: (1) they express and conserve the team's elicited user needs, insights, and design decisions; (2) they are used to elicit further needs and requirements through testing; (3) they challenge assumptions and constraints; and (4) they communicate ideas to stakeholders and within the project team. In our study, each case created between 23 and 52 low- to medium-resolution prototypes to express functional requirements in order to determine *what* should be done, and non-functional requirements to examine *how* the solution should work and look like. Hence, functional requirements were mainly explored through testing form and features of the prototype; non-functional requirements were mainly discovered through the actual interaction with it. Pictures 1-4 illustrate the variety of prototype forms (from left to right): a low-resolution "Wizard-of-Oz"-prototype tested the interaction with a digital avatar (Case H); a role-play examined an aspired service scenario (Case K); paper-based wireframes evaluated core features of an app (Case L); a user journey assessed daily touchpoints with a banking app (Case I). Meeting memos show a project member's perception, by stating "*it is easier to talk with the help of prototypes and refine ideas to sharpen the overall concept*" (Case I). We find that using Design Thinking, which encourages the continuous creation of low-resolution prototypes, can help overcome some of the mentioned challenges in requirements elicitation. Particularly, we acknowledge their potential to enhance creativity of requirements (C2), to translate needs into technical requirements in a more precise way (C3,10), to ease communication with stakeholders (C4), to expose tacit knowledge (C5), and finally (4) to faster adapt to changing requirements (C8), and thus, to increase the effectiveness of requirements elicitation overall.

Pictures 1-4. Low-resolution prototypes from early project stages

Learnings regarding Quality of Requirements

Learning 5 – Design Thinking enhances the priority of eliciting non-functional requirements with a special focus on user experience. Our results suggest that Design Thinking creates an enhanced priority of eliciting user needs and requirements in terms of usability (context of use), workflows (workflows and tasks performed by the user), and user interface (interaction flow or screen layout). However, we also observed a lack of eliciting other non-functional requirements such as security, safety, or performance in our cases. In terms of user experience, Case A distinguishes functional (given and discovered) and so-called experiential requirements *"to define the emotions that the final concept must evoke in its users,"* i.e. how the solution should eventually *feel like*. Case G, a B2B project to improve aircraft maintenance by connecting demand and supply on a platform, approached emotional aspects via mood boards to inspire the ease of use and to enhance fast decision-making processes for users in a time- and cost-sensitive, high-pressure environment. Moreover, Case D made it their mission to "*make people management a daily experience*." The team identified user experience as one key requirements to guarantee usage on a regular basis. With the help of persona storytelling, they prioritized usability and workflow requirements in every development step to transform "*an improved user experience to an outstanding one*." Relating these findings to existing elicitation practices and challenges, we find that the strong user focus leads to a thorough examination of the user experience, and, thus, to an enhanced priority for eliciting non-functional requirements. In this context, we especially see potential to weaken Challenges 3 (translation) and 7 (invented requirements). However, as we also need to report the neglect of other (non-functional) requirements, which are essential

for later-staged software implementation, we expect higher completeness of requirements (C10) when both methodologies are applied complementarily.

Learning 6 – In Design Thinking, context is about the human, not the system. Elicitation activities focus on understanding stakeholders and their context, regardless of the future solution. This means, they are considered "humans" first and "users" second. Methods to capture context variables are, among many, personas, mood boards, or contextual interviews. In Case A, for example, the team used an empathy suit to mimic limited moving capabilities of an MS patient (Pictures 5 and 6). Thus, independent from the specific context of the future solution (which was explored at a later stage), the team, first, gained deeper empathy for the daily impairments in their living context in general. Another team improved their understanding of the main target group, i.e. doctors, by widening the exploration context to influential parties like hospitals, pharmacies, and patients (Case C). In this vein, the team put the focus on the relevant stakeholders of the challenge and created the vision to *enable a trustful and efficient exchange between doctors and pharmaceutical companies*, stemming from the original problem statement to re-design the go-to-market model for prescription medicine products. We find that this way of approaching problems could contribute to overcome several elicitation challenges in terms of creativity (C2), communication issues (C4), tacit knowledge of stakeholders (C5), and requirements quality (C7, 8, 10). However, this might also require a profound mindset shift for (some) analysts as the process might feel too lengthy or not focused enough.

Picture 5. Empathy suit of an MS patient I

Picture 6. Empathy suit of an MS patient II

Learning 7 – Design Thinking takes a holistic view on requirements elicitation for a domain-agnostic solution. In general, the application of Design Thinking is not only domain-agnostic in the problem domain (i.e. applicable to a variety of domains), but also in the solution domain (i.e. solutions can be developed via different types of artefacts, only one of them being IS). Subsequently, Design Thinking is able to take a holistic perspective on analyzing the real world, including multiple domains, interacting systems, and stakeholders. We find evidence from several cases that domain knowledge is by far not enough to tackle the given problem statement. All cases show a broad problem exploration with the help of stakeholder mapping, desk research, interviews and observations, benchmarking, and trend research. Notes from a team member in Case A summarize the value of these activities: *"After spending weeks exploring the problem, interviewing and talking to patients and others, I got a much clearer picture of what MS is, the complex problem and dimensions we are dealing with, and, finally, I can see what we need to address their challenges."* We observed that the teams were not constrained by the preconception of software solutions too early which enabled them to discover unknown solutions that might not even be a digital one, if best for the user. Overall, we found that most solutions of our cases require an integration of software, service, and/or hardware components to create a compelling user experience. In our case, all solutions combined software and service components; some included a hardware component. The final system of Case C comprised an application for mobile devices, an online platform, and a physical device for doctors' desks. Summing up, we see the potential of Design Thinking to support established requirements elicitation practices by looking beyond the system and domain context to generate solutions with a comprehensive user experience in a broader service and product environment. We expect positive influence, mainly for elicitation challenges regarding lack of creativity, (C2) tacit knowledge extraction (C5), and invented requirements (C7). However, similar to learning 6, this also requires a mindset.

Discussion, Contributions, and Limitations

The aim of our research is to investigate the learning potential of Design Thinking to boost requirements elicitation in software-intensive projects. We use empirical findings on challenges in requirements

elicitation practices to guide the analysis of 12 cases applying Design Thinking. Our key learnings address challenges regarding *process guidance*, *stakeholder communication*, and *requirements quality*. First, we see high learning potential for the requirements elicitation *process* that many researchers criticize to be insufficiently guided (e.g., Browne & Rogich 2001). To enhance creativity, Design Thinking provides a clear distinction between exploring needs and requirements and fosters continuous re-framing of problem- and solution domain. In addition, we find the guiding framework to support the practical application of methods, which might even compensate for the lack of an analyst's experience. However, as Design Thinking is a team-oriented approach that strongly relies on the individual expertise of people, we regard limited capabilities as a critical success factor of Design Thinking as well. Second, low-resolution prototypes are considered an effective way to ease communication with and expose tacit knowledge of stakeholders and thus, to address c*ognition- and communication-related* challenges that have been raised in various studies (e.g., Zowghi & Coulin 2005). Third, Design Thinking faces *quality* challenges, as do current elicitation practices, in terms of the traceability, correctness, completeness, and consistency of requirements. Yet, it emphasizes the discovery of user requirements to derive a comprehensive user experience. Continuous interaction with stakeholders supports dealing with changing requirements and decreases invented requirements that are not based on user needs. All of this might then even lead to generating a solution completely different from what was originally intended. To that effect, we consider Design Thinking particularly supportive for addressing complex problems as Brown (2008) mentioned. For well-defined problems, i.e. when the real-world problem is known, the application of the entire Design Thinking process might be "over-engineered". Even so, we strongly feel that an enhanced mindset for a more human-centered way of requirements elicitation proves beneficial either way and "minimizes the risk of delivering a system that does not meet its stakeholders' needs" (Glinz 2014, p.12).

The contribution of our research is threefold. First, we advance the understanding of how Design Thinking can support problem-solving in IS by providing robust empirical evidence of its role for requirements elicitation. Scholars may build on our findings to derive concrete propositions from each learning and quantify their effects. As we mainly focused on discussing the *what* of each learning, we suggest to also consider the concrete *how*. In that vein, the distinction of Design Thinking as a process, toolbox, and mindset (Brenner et al. 2014) provides a differentiated guideline to follow. Second, Yoo proposes IS scholars to "help Design Thinking practice by inventing new constructs, models, methods, and instantiations" (2017, p. v). We hinted at evidence suggesting that (methods of) both approaches might be best applied complementarily in an iterative dialogue to inform and influence each other. We encourage other researchers to evaluate such an integrated approach. Third, we make a valuable contribution for all, not just the most experienced practitioners, to avoid aforementioned challenges and gain improved appreciation for eliciting requirements with Design Thinking. In this regard, we strongly believe, that Design Thinking not only provides new structures and methods to enhance elicitation efforts, but also induces a mind-shift to a more human-centered and explorative way of requirements elicitation.

Despite the careful design of our study, we are aware that our paper is not without limitations. We acknowledge biased selectivity as one limiting factor for document analysis (Yin 2011). Although we conducted our analysis in a near-real life setup (real problems provided by real corporate sponsors), it can be argued that the sources of evidence are closely aligned with the specific Design Thinking approach of the University, including its particular assessment policies and Design Thinking philosophy. In addition, all project teams were composed of students being novices in Design Thinking. Therefore, we encourage scholars to investigate project teams in actual organizational settings as we expect organizational factors like resource allocation, organizational stability, or organizational implementation of Design Thinking to influence requirements elicitation. Nevertheless, we strongly believe that the access to the vast amount of confidential and detailed data in our study outweighs its limitations because it led to a first profound understanding of the role of Design Thinking for requirements elicitation.

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