

# Towards an Understanding of Benefits and Challenges in the Use of Design Thinking in Requirements Engineering

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## ABSTRACT

Agile approaches arose as a way of addressing some of the main challenges in software development. Some of the challenges are changing requirements, lack of understanding about the system's scope, and out-of-sync between code, requirements, and documentation. Software companies' professionals have adopted Design Thinking (DT) to support software development to understand better what customers want, fostering the creation of features and products. Due to the importance of requirement engineering to software development success, this study aimed to characterize what DT benefits and challenges were perceived in requirements engineering by the Brazilian software development community. The current study used mixed methods combining two qualitative methods, a focus group to collect and understand the professionals' DT usage opinions and a survey to confirm the professionals' challenges and benefits. This study identified that DT has helped the professionals improve the requirements gathering and specification, reflecting on better users' real needs understanding and building fittable solutions to support them. The results serve to understand better DT potential, perceived by software industry professionals, to anticipate and support these issues with other professionals.

## CCS CONCEPTS

• **Software and its engineering** → **Requirements analysis**;

## KEYWORDS

Design Thinking, Software Development, Requirements Engineering, Empirical Study, Benefits, Challenges.

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## 1 INTRODUCTION

Software development has become more dynamic and adaptive, using agile methodologies in organizations in the last years [30]. The software industry faces the challenge of creating innovative requirements to equip the software with competitive advantages [2]. Furthermore, studies point out that software companies continue to develop products that do not meet the user needs [1] and still face challenges in software development, such as stakeholders identification, communication gaps, lack of requirements consistency [33], among others.

In this context, Design Thinking (DT) comes to support developers in understanding users' real needs [31]. DT aims to group a set of practices inspired by *Design* for product development, using empathy, creativity, and rationality to meet users' needs and achieve organizational goals [32]. DT covers steps where each one can contain techniques to support during the generation of ideas and transformation of those solutions [19].

Some authors discuss the importance of DT for features creation [32]. Despite theoretical and practical advances, we still do not have much knowledge related to the integration of DT in the context of software development [13]. The use of DT to aid software development activities fosters human-centered solutions more effectively and, therefore, it is important to know in-depth about how organizations have adopted DT for their activities [12, 13]. One of the problems that requirements engineering has tried to solve is how to turn a problem into possible solutions [31].

This study combines two qualitative research methods, a focus group, and a survey. We used them to characterize what DT benefits and challenges were perceived in the requirements engineering Brazilian software development community. This investigation allowed us to answer “**What were the perceived benefits and challenges of DT adoption in requirements engineering?**”.

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Thereby, seven focus groups were conducted [23], totaling 39 professionals. Also, 158 professionals responded to our survey.

Our results demonstrated that DT has helped to improve the requirements gathering and specification, increase collaboration and communication, promote a better understanding and identifying real needs reflection in better solutions. However, there are DT challenges such as lack of DT valorization, lack of time to sufficiently explore the real needs, lack of professionals with DT experience, lack of people engagement, and others.

The paper is organized as follows: Section 2 presents the background. Section 3 details the research method with the details of this study. Section 4 reports the preliminary results that emerged from our studies. Section 5 discusses the main findings and explores the paper contribution. Section 6 presents previous studies and a comparison with our results. Section 7 lists our recommendations, and Section 8 has the final considerations and limitations.

## 2 DESIGN THINKING IN REQUIREMENTS ENGINEERING

Design Thinking (DT) is defined as a human-centered approach, which uses a toolkit to integrate people's needs, technological possibilities, and business success needs [4]. Several DT models have emerged to support the distinct problems that DT proposes to solve [24]. Hence, studying the models and their DT steps are important because they combine the best of approaches to building software with high-quality [29].

DT has gained recognition as a problem-solving approach that relies on interdisciplinary teamwork, exploration of human needs, rapid prototyping, and interactive learning cycles in the earlier stages of product, service, and development processes [4]. DT is seen as one of the most effective ways of understanding needs, aiming to empathize with users and understand the context of use [32]. Although there are several definitions for DT, they all gravitate in the same philosophy that encompasses creative thinking, contextual knowledge, and scenarios to apply a possible solution [18].

DT focuses on interdisciplinary teamwork, exploration of human needs, rapid prototyping, and interactive learning cycles in the early stages of product, service, and system development processes [4]. Moreover, DT can be defined by three phases [5]: 1) Immersion is divided into two stages: a preliminary immersion focuses on re-framing and understanding the problem and the stakeholders. Also, an in-depth immersion focuses on a research plan to investigate the context and stakeholders. These techniques support the understanding of related context to explore through the project; 2) Ideation is to generate new ideas and solutions to evaluate through the project. It can use brainstorming around the topic to collect ideas, document, and validate an initial solution; and 3) Prototyping supports ideas validation; it can be conducted parallel with the immersion and ideation phases through the project.

DT and requirements engineering are distinct in their philosophies, but many artifacts are complementary or even overlapping; DT follows a philosophy of domain understanding and the learning curve leading to it [12]. Software requirements describe which services, constraints, and characteristics a system must provide and specify the knowledge needed to develop it. Requirements engineering is a systematic process that involves elicitation, analysis, and

negotiation, documentation, validation, and requirements management [16]. In requirements engineering, DT provides a methodology for eliciting user needs and produces a series of prototypes that normally converge to solutions [31].

DT has been used to support requirements engineering activities by (a) adding a strong focus on the customers and user's needs, (b) integrating an agile and flexible procedure for solving wicked problems, and (c) providing a guiding to foster creativity for development teams. It is also highlighted that DT is compliant with the requirements engineering and that the use of rapid prototyping and customer involvement is consistent with the agile methods. It supports documentation and team management, one of the main focuses of the agile methods [31].

## 3 RESEARCH METHOD

We applied mixed methods research [7] combining two qualitative research methods, a focus group, and a survey. We used them to characterize what DT benefits and challenges were perceived in the requirements engineering Brazilian software development community. This section presents the settings of the methods from the planning through the analysis.

### 3.1 Focus Group

We opted to conduct Focus Groups to collect and understand experts' opinions [23] and contrast the divergent opinions among the professionals, building a common understanding. We looked for professionals who use or have used DT to facilitate/support their projects/products. We looked for Brazilian professionals in companies at TECNOPUC (Technology Park located at PUCRS University) in DT online groups and among professionals from the LinkedIn network during the professionals' selection. Additionally, some professionals were indicated by candidates (snowballing).

We used two data sources to conduct this study. These scripts used a face and content validity with an invited researcher with previous experience working with DT in the industry. The focus groups were held between February 2019 and April 2019.

We present each data collection method and its related purpose within our study, as follows: 1) Questionnaire: Each professional filled an online questionnaire to inform his/her background (e.g. name, experience, among others). 2) Focus group: In each session, we presented our research objectives and requested the professionals for their consent to video record the sessions and allow transcriptions. During the sessions, the moderator (who has 11 years of experience in the software industry, with practical and theoretical DT experience, and one of the authors of this paper) presented the questions, through a presentation in slides, as follows:

- What are the perceived benefits of DT adoption in requirements engineering?
- What are the perceived challenges of DT adoption in requirements engineering?

We obtained seven sessions, with an average of six professionals per session. Five sessions were co-localized and two were remote. The remote sessions made it possible to identify the understanding of use by professionals from different locations in Brazil, in Table 1.

Each session had an average of 88 minutes of duration. The largest was 110 minutes, and the lowest was 65 minutes. In this

**Table 1: Focus Group Professionals**

ID	Role	Org Size	Yrs at Org / DT	Previous Experience	Context
P01	Facilitator	SE	2/5	Product	Technology
P02	Facilitator	SE	3/3	Product, Dev, Manager	Technology
P03	Lead UX/UI Designer	LE	13/4	Product, Dev, Designer, Manager	Technology
P04	Developer Manager	GLE	8/1	Product, Dev, Manager	Technology
P05	Manager	LE	5/3		Financial
P06	Research Designer	LE	3/10	Designer	Technology
P07	Experience Designer	SE	1/1	Designer	Technology
P08	Experience Designer	ME	11/8	Dev, Designer, Manager	Technology
P09	Marketing Analyst	SE	2/2	Product, Dev, Manager	Technology
P10	Product Design Specialist	ME	1/4	Designer	Technology
P11	Support Analyst	GLE	5/2		Technology
P12	UX Designer	LE	3/3	Product, Designer	Technology
P13	Software Developer	GLE	3/3	Dev	Technology
P14	Technology Director	SE	14/5	Product, Designer, Manager	Technology
P15	Service Designer	ME	3/5	Designer	Technology
P16	Design Thinker	SE	4/4	Product, Manager	Technology
P17	UX Designer/Product Manager	SE	1/3	Designer	Technology
P18	Technology Director	LE	2/10	Product, Dev, Manager	Technology
P19	Design Evangelist	GLE	4/7	Product, Dev, Designer	Technology
P20	UX Research Analyst	GLE	1/3	Product	Technology
P21	Product Designer	LE	2/6	Designer	Technology
P22	Technology Leader	GLE	8/5	Product, Designer	Technology
P23	Business Analyst	LE	5/1	Product, Dev, Tester	Technology
P24	Product Designer	LE	4/10	Product, Designer, Manager	Technology
P25	UX Leader	LE	3/3	Designer	Financial
P26	Innovation Director	SE	1/4	Designer	Technology
P27	Sales Representative / Design Thinker	SE	2/2	Product, Manager	Technology
P28	UX Consultant	SE	4/6	Designer, Manager, Tester	Technology
P29	Service Designer	GLE	6/6	Designer	Financial
P30	UX Researcher	LE	3/6	Designer	Technology
P31	Lead UX Researcher	ME	1/2	Product, Designer, Manager	Technology
P32	Innovation Facilitator	LE	13/1	Product, Dev, Designer, Manager, Tester	Financial
P33	CEO	ME	6/4	Designer, Manager	Technology
P34	UX Designer	LE	1/4	Designer	Technology
P35	Entrepreneur	GLE	3/4	Product, Dev, Manager	Technology
P36	Scrum Master	LE	3/4	Product, Manager, Tester	Financial
P37	Technology Consultant / Facilitator	SE	10/2		Technology
P38	Business Analyst	LE	7/1	Product, Tester	Technology
P39	Entrepreneur	SE	4/8	Product, Designer, Manager	Technology

study, we had 39 professionals distributed in seven Focus Group sessions. We had the largest session with seven professionals and the smallest with four professionals.

Table 1 shows the professionals' characteristics such as professional's role; the size of the organization (Org) - e.g. E for small enterprise, M for medium enterprise, L for large enterprise and GL for global large enterprise; time of performance working in the organization by the time of DT usage; previous experiences - e.g. Product to represent an Analyst or a Product Owner, Dev to represent a Developer or a Tech Lead and Designer to represent UX or UI Designer; company's context and professional's location.

All transcriptions were analyzed using the content analysis technique based on Krippendorff [17], organized into the following

steps: organization and pre-analysis, reading and categorization, and recording the results. Hence, it aims to reveal the perspective and patterns of behaviors among professionals. The analysis process was made by three collaborators individually. After that, these different perspectives converged in a wider vision about the comprehension of these findings.

### 3.2 Survey

The survey [15] aimed to confirm what the benefits and challenges were perceived by the professionals. We designed the questions based on data gathered previously through a systematic literature

mapping. We designed a questionnaire as a data collection instrument, using Qualtrics<sup>1</sup> tool. Our target audience was Brazilian professionals who have experience in DT in software development. We looked for professionals on *LinkedIn*. Part of this study was published in [26], which had 127 answered and other perspectives; this paper used the following questions:

- What are the perceived benefits of DT adoption in requirements engineering?
- What are the perceived challenges of DT adoption in requirements engineering?

The survey's period ranged from September 2019 to December 2019. During this period, the survey was sent to 466 professionals, with 158 who responded; the response rate was 33,9%. 67,7% (107) of respondents had between one and three years of experience using DT, and 32,3% (51) of the respondents had more than four years of experience. Also, 49% had more than eight years of experience in the Information Technology field. Agile Coach, UX/UI Designer, and Facilitator represented 64% of the respondents' roles.

## 4 RESULTS

This study was based on two qualitative methods. This section presents the emerged results of them.

### 4.1 Focus Group Results

We divided into two questions to analyze benefits and challenges, one aimed at analyzing DT benefits and the other one challenges. We performed codes and mapping of these codes representing the insights of the 39 professionals, as shown in Table 1.

#### ***What are the perceived benefits of DT adoption in requirements engineering?***

The needs understanding is important to align the requirements and define a solution. Many professionals report that DT encourages learning among all stakeholders – "(...) when you evaluate a demand, the time spent is not thrown away in the trash, because the learning process is a return to the company." (P09) and it influences to decrease a lack of understanding – "we build trusting relationships when we are co-creating together because people know and understand each other better." (P12).

They mentioned that DT builds better solutions – "currently, we do not build solutions based on singles definitions, we are building solutions together with people who need them, so it improves the deliverable" (P38). Also, they reported that DT is adding value on deliverable – "When you focus on the user, allowing the perspectives' and processes' sharing. You will consolidate it and deliver big value." (P21) and – "we can feel in our soul. When you are delivering something and the person who will use your solution accepts your solution with a smile, this is the great deliverable." (P32). Some of them reported better requirements with DT usage – "DT practices promote perception of business requirements" (P27).

There are ways to create a collaborative environment; the cooperation among the people is crucial to discover the needs and understand the whole process. The professionals mentioned that DT is engaging people to create better relations among them – "(...)

people understand that looking and listening to the people is the most important thing." (P07) – "When you conduct DT, you can see that people empathize with what the other people do." (P39). They highlighted that DT incentivizes empathy among people, so they can connect, defining the solution together – "People understand that looking at each other and listening to each other is one of the most important parts" (P07) and improves communication – "DT improves communication and the relationship between participants" (P33). Some of them mentioned that DT builds a human-centered mindset in the organizations – "DT changes the point of view of perceiving things, evolving the culture and changing the way we solve problems." (P25)

#### ***What are the perceived challenges of DT adoption in requirements engineering?***

It is important to have an in-depth understanding of the needs to define a solution. However, professionals mentioned that some pre-designed solutions are defined as a solution without problem understanding. They highlighted the importance of respecting people's insights – "People always try to solve the problem without the problem' analysis. You ask, 'what is it?' And they answer 'I have a solution for that, we do not need to lose time.'" (P39). They mentioned difficulties to lead those who make decisions because they want control over the decisions, not allowing people's insights emerge – "depending on the organization's culture is hard to break the culture of the managers and coordinators need to control all decisions in whole flow." (P36).

They highlighted a difficulty to engage key people to explore a whole process – "You do not advance the scoping process if you do not have the people you need" (P18). Some of them mentioned that the person who is a moderator during the co-creation, needs to maintain neutrality, leaving its bias aside, as described into "(...) you have to be neutral, not influencing the people, because it is easy who is facilitating to lead as 'Ah, I want that one!'" (P08).

Also, they mentioned the selection of a multidisciplinary group and engage all members are a challenge because they do not actively participate – "(...) professionals with a high hierarchy are participating in the dynamics but they are not present, they are on cell phone, looking their e-mails, calling, leaving the place, instead of collaborating and participating in the discussion." (P23).

Many professionals mentioned a lack of valorization in DT – "For me, the main difficulty is the appreciation of DT by the company and sometimes the team too because they do not see the value that can be obtained" (P19). There are cultural barriers of some organizations to adopt DT – "Several people in a workshop during few days, usually companies can not see value on it, it is a cultural issue." (P33) and – "Some people think that if you are using post-its and working standing, then you are not working, do you know?" (P07).

### 4.2 Survey Results

The survey was analyzed using open questions responded by professionals. They highlighted the following benefits and challenges:

#### ***What are the perceived benefits of DT adoption in requirements engineering?***

Professionals mentioned their perceived benefits in DT usage, illustrated in Table 2. 68% (103) of them reported DT usage to

<sup>1</sup>www.qualtrics.com

**Table 2: List of Benefits**

ID	Benefit	Frequency of citations
SB01	Increase collaboration	37,3% (59)
SB02	Better understanding	36,1% (57)
SB03	Identification of real needs	15,2% (24)
SB04	Assertive software solution definition	15,2% (24)
SB05	Increase creativity	9,5% (15)
SB06	Greater empathy	8,9% (14)
SB07	Process efficiency	6,3% (10)
SB08	Decrease uncertainty	3,2% (05)
SB09	Decrease the time and money spent	2,5% (04)
SB10	Promote a cultural transformation	2,5% (04)
SB11	Improve communication	1,9% (03)
SB12	Decrease time to fail	1,9% (03)
SB13	Decrease understanding gap risks	1,3% (02)
SB14	Improve requirements definition	0,6% (01)

understand and specify the requirements. Specifically, about the requirements, some of them highlighted a better requirements understanding reflects in better requirements – *“Better understanding of the main needs of the end-user and therefore better requirements”* (R46); the collaboration improves the requirements definition – *“The generated collaboration improves the understanding of the problem, as well as the definition of requirements.”* (R99) and DT promotes a collection of requirements – *“The use of DT facilitates the collection of requirements and causes the solution to be built together with the customer”* (R137).

Besides, 37,3% observed an increase in collaboration among the stakeholders, and 36,1% identified better problem understanding. Also, 15,2% highlighted the possibility of identifying real needs and build the right software solution. 9,5% cited that there is an increase in creativity and 8,9% greater empathy.

Besides, 6,3% highlighted the efficiency of the process, and 3,2% observed a decrease in solution uncertainty. 2,5% reported a decrease in the time and money spent and a cultural transformation. Less than 2% mentioned the following benefits: improve communication, decrease time to fail, decrease understanding gap risks, and improve requirements definition.

**What are the perceived challenges of DT adoption in requirements engineering?**

Professionals answered their perceived challenges in DT usage in requirements engineering, illustrated in Table 3. We identified that the time dedicated and people engagement to explore the needs reflect better requirements and solutions.

However, 19% of professionals reported a challenge to have enough time to apply DT and 16,5% identified a lack of engagement of people during DT. Also, 14,6% highlighted a lack of value in DT approach, 9,5% need a cultural transformation to adopt DT, 8,2% identify a lack of professionals’ knowledge to adopt DT, 7,6% mentioned difficulties in discovering and understanding the problem first because there is insufficient time to do it, 6,3% said that engaging a multidisciplinary team is complicated because of the availability of agendas and interest to do it, 5,7% identified a low maturity to use DT, 5,1% highlighted that finding professionals with

**Table 3: List of Challenges**

ID	Challenge	Frequency of citations
SC01	Enough time	19,1% (30)
SC02	People engagement	16,5% (26)
SC03	Lack of value	14,6% (23)
SC04	Need a cultural transformation	9,5% (15)
SC05	Lack of knowledge	8,2% (13)
SC06	Understand the problem first	7,6% (12)
SC07	Engage a multidisciplinary team	6,3% (10)
SC08	Low maturity to use DT	5,7% (09)
SC09	Professional with DT experience	5,1% (08)
SC10	Converge the insights	3,2% (05)
SC11	Resistance to adopt DT	2,5% (04)
SC12	Data transformation	1,9% (03)
SC13	Adapt DT in each context	1,3% (02)
SC14	Lack of empathy	1,3% (02)
SC15	Investment of money	0,6% (01)
SC16	Old architecture	0,6% (01)
SC17	Lack of viability to build the solution	0,6% (01)
SC18	Align all stakeholders’ expectations	0,6% (01)
SC19	Map all stakeholders	0,6% (01)
SC20	Use in complex situations	0,6% (01)

DT experience is hard, 3,2% presented difficulties in converging all stakeholders’ insights.

Less than 2% mentioned difficulties to transform data correctly, adapt DT in each context because there are many kind of contexts, lack of empathy among the people, invest money in DT usage, build new solutions based on old architecture, lack of viability to build the solution, align all stakeholder’ expectations, map all stakeholders necessary to participate though the discovery and delivery cycle and use DT in complex situations.

**5 DISCUSSION**

We identified that there are some benefits that can mitigate some requirements challenges. DT usage can get closer to people and encouraging communication. It can mitigate a literature challenge about a lack of moments for stakeholders to share a common understanding of concepts and terms [33].

We identified the survey findings reinforce some benefits that emerged from focus groups, as follows: a) engaging people, it reflects on better cooperation among people, and it is crucial to explore and identify the real needs; b) encouraging learning, it allows to align the needs, requirements and has a better solution definition; c) adding value on the deliverable, it is important to deliver value to the business and users, it avoids waste of time and money; and, d) building a human-centered mindset promotes a cultural transformation through the software development process.

The empathy caused by DT usage supports the understanding, encouraging a tacit knowledge sharing among stakeholders, mitigating a literature challenge in stakeholders can not express their needs or requirements clearly about the topic [33]. Also, DT is adding value to deliverables, extending the finding from literature such as understand the real problem [13] and solve practical problems [4], reflecting needs in better solutions and promoting satisfaction among stakeholders.

**Table 4: Related work**

	<b>Martins et al. [22]</b>	<b>Canedo et al. [6]</b>	<b>Hehn and Uebernickel [13]</b>	<b>Prasad et al. [25]</b>	<b>Rauth, Carlgren and Elmqvist [27]</b>	<b>Lucena et al. [20]</b>	<b>Our Study</b>
Objective	Collect the challenges in software requirements elicitation in agile methodologies and the use of DT	Build a broad comprehension of how practitioners use the DT tools and characterize how they notice their significance along the software development	Identified how IBM uses DT	Explored how effectively use DT practices with agile process	Explored how DT is used in large organizations	Identified how IBM uses DT	Identify how the professionals are adopting DT, their perceived benefits and challenges
Method	Triangulation based on bibliographic research, observation, questionnaire and interview	Online survey, totaling 59 answers	Case study	Case study in the software development industry with 15 employees in Sri Lankan	Interviews with participants from 16 companies	Survey about five projects	Seven focus groups, totaling 39 professionals, and a survey with 158 answers
Benefits	Strengthens stakeholders' participation in the definition, detailing, validation, interdependence and prioritization of requirements, mainly in the prototyping; in the estimation of the schedule; and in the planning of the initial activities	Enhancing the requirement elicitation process; Allowing errors identification in requirements understanding from prototyping; Easying implementation once that prototypes are validated directly with clients	Integration among stakeholders, better usability requirements elicitation and different viewpoints shared for an in-depth requirements elicitation	Improve customer satisfaction with the use of DT practices in agile-base projects	n/a	DT brings up-front analysis and user feedback in all the iterations offering a better understanding of what problems need to be solved and what are the best solutions to satisfy the user needs	Increase value on deliverable, collaboration and communication, better understanding, greater empathy, identify real needs, better requirements definition, increase creativity, human-centered mindset, cultural transformation and process efficiency
Challenges	Non-functional requirements discussion among stakeholders, use of artifacts, and change of requirements	n/a	n/a	Unable to prioritize what customer wants, compare the product with similar products without considering its applicability for the future and requirement changes in a limited budget	n/a	n/a	Pre-designed solutions without understanding, lack of DT valorization, lack of enough time, lack of professionals with DT experience, people engagement, low maturity to use DT, and cultural barriers

We identified the survey findings reinforce some challenges that emerged from focus groups, as follows: a) pre-designed solutions are defined without understanding problems first; b) engage people to explore the needs and process; and, c) cultural barriers and lack of DT value these influence resistance to using DT in the right way. Also, DT benefits are collected when its application is encouraged.

We found some challenges, such as a lack of time and a lack of engaging people because some preconceived ideas or decision-makers can influence DT usage. After all, it can distort the real needs. In the literature, we can see that DT incentives to share the perspectives in a multidisciplinary team highlighted by [13], but we identified that when we have some barriers to avoid this sharing, it influences the final results. Also, a person who leads DT without neutrality can influence the final solution, reflecting in the invented needs highlighted by [14]. Also, we confirmed that there is a lack of professionals with DT experience. This lack was identified by [11], they find that analysts are not equipped with sufficient experience (e.g. wrong choice of techniques) or ability (e.g. lack of social skills) to perform effective requirements elicitation.

We confirmed that DT supports requirements change over time for various reasons, such as new market trends, feedback from coding revisions, resource constraints, or the influence of new business requirements. This finding was identified by [10]. Also, we observed organizational cultural aspects that difficult DT usage; some companies are thinking that a group in a room for a few days is time-wasting. It can influence a lack of DT valorization, not taking advantage of the approach's potential, confirming a finding from literature about changing mindset as a challenging task to do in organizations, identified by [8].

In both our studies, we identified three perceived benefits 1) increase collaboration, 2) cultural transformation, and 3) decrease time to fail equivalent to three perceived challenges 1) lack of people engagement, 2) need a cultural transformation, and 3) lack of enough time. Our findings suggest that at the beginning of DT usage in a company when they do not have this culture, these challenges are common, but after the first projects, using DT, the company sees the value, and people start to recognize it. Given the number of possibilities of DT application in software development, we identified that the benefits that emerged from our study mitigate some requirements challenges. Also, DT cannot be applied successfully if the company does not incentivize DT usage to solve problems.

## 6 RELATED WORK

We identified studies discussing how DT is being used in requirements engineering and software development. Martins et al. [22] analyzed the use of DT to see if it fits properly to solve the challenges of elicitation of software requirements when using agile methods, so they identified that DT could mitigate some of them. Also, Canedo et al. [6] highlighted that DT practice in requirements elicitation could contribute to delivering product quality to the end-user since DT techniques could prevent failure in understanding requirements before implementation. In our findings, we confirm it too. Rauth, Carlgren and Elmqvist [27] discussed that DT can be understood as an innovation approach, a process to develop new ideas, a mindset, or a combination of mindset and methods.

**Table 5: Recommendation for practice**

Our finding	Recommendation
+ Better understanding	To have many insights and perspectives, we suggest that different roles participate, interdisciplinary team [3], considering each working space through DT.
+ Improve the requirements	To specify the requirements, we suggest understanding the business and its needs.
+ Decrease uncertainty	To have a place with all insights, we suggest reserving a room (virtual or physical) for everyone to follow the process's evolution.
+ Increase collaboration	To conduct DT, we recommend engaging all stakeholders.
- Pre-designed solutions	To increase creativity, we suggest using ice breakers and material to incentivize, similar to using modeling clay.
- Lack of people engagement	To engage people in DT, we recommend sharing the knowledge about the approach, explaining how to apply DT, providing material/workshop/training to educate professionals.
- Lack of value	To increase the value in DT usage, we suggest collecting, presenting, and sharing results identified during the projects.
- Lack of knowledge	To overcome bad experiences with DT, we recommend that you practice it, improving your experience and knowledge.
- Low maturity to use DT	To choose the techniques [21], we recommend discovering and understanding your goal first because DT usage depends on the context.
- Lack of enough time	To identify, evaluate, and explore real problems; we recommend reserving enough time to do it.
- Cultural barriers	To mitigate the cultural barriers, we suggest starting and trying DT usage to build a design mindset.

Lucena et al. [20] identified improvement in goal definitions and deliver better results. Prasad et al. [25] derived a framework from achieving customer satisfaction through the adoption of DT in agile-base projects. Hehn and Uebernickel [13] highlighted the integration among stakeholders, better usability requirements elicitation, and different viewpoints shared for in-depth requirements elicitation during DT.

In line with these findings, we identified the same ones in our study, in Table 4. Also, our study extends these findings because we identified a cultural transformation as a benefit and some challenges like cultural barriers to start DT adoption, lack of DT valorization, enough time to explore the real needs, lack of professionals with DT experience, people engagement, and others.

## 7 RECOMMENDATIONS FOR PRACTICE

Based on our findings, we present the following recommendations to share with those who desire to use DT for requirements engineering in software development. The recommendations are based

on our findings and literature, illustrated in Table 5. Our findings are represented as a benefit (+) and a challenge (-).

## 8 FINAL CONSIDERATIONS AND LIMITATIONS

We conducted focal groups and surveyed software industry professionals from different contexts to characterize what they perceived the benefits and challenges. This study showed that the benefits that emerged from the use of DT could support some identified challenges. So, DT adherence causes organizations to transform themselves by focusing on understanding their users' real needs and building software to support them. We encourage researchers and practitioners to use DT in their contexts to mitigate some challenges, but they need to take care of DT challenges.

Focus groups [23] have typical limitations of qualitative studies, mainly in the generalization of results [28]. We counted on the cooperation of 39 professionals, professionals who use/used DT for software development, which influenced the generalization of the final results. Even if the generalization is not possible, these data are valid and complemented with other studies. According to [9], the difficulty with focusing on the process, or methods, is that processes are rarely mechanically followed in practice. We faced this issue because different professionals' perspectives use DT in different contexts.

We cannot generalize our survey because we conducted the survey only in Brazil, and the answers may only represent the professional's view and not the whole organization. However, these limitations indicate opportunities to replicate it in different countries and contexts. We highlighted that the samples were significant, but they were not representative because it is important to have an increased number of professionals.

Future work aims to understand the consequences of DT adherence to mitigate inherent requirements engineering challenges. Also, it needs to focus on investigating DT adoption, aiming to evaluate DT approach potential.

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## REFERENCES

- [1] Carmelo Ardito, Paolo Buono, Danilo Caivano, Maria Francesca Costabile, and Rosa Lanzilotti. 2014. Investigating and promoting UX practice in industry: An experimental study. *International Journal of Human - Computer Studies* (2014), 542–551.
- [2] Tanmay Bhowmik, Nan Niu, Juha Savolainen, and Anas Mahmoud. 2015. Leveraging Topic Modeling and Part-of-speech Tagging to Support Combinational Creativity in Requirements Engineering. *Requirements Engineering* 20, 3 (2015), 253–280.
- [3] Walter Brenner, Falk Uebernickel, and Thomas Abrell. 2016. *Design Thinking as Mindset, Process, and Toolbox*. Springer, St. Gallen, Switzerland, 3–21.
- [4] Tim Brown. 2008. Design Thinking. *Harvard Business Review* (2008), 84–95.
- [5] Tim Brown. 2009. *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*. HarperCollins, London, UK.
- [6] Edna Canedo, Ana Pergentino, Angelica Calazans, Frederico Almeida, Pedro Costa, and Fernanda Lima. 2020. Design Thinking Use in Agile Software Projects: Software Developers' Perception. In *Proceedings of International Conference on Enterprise Information Systems*. 217–224.
- [7] John Creswell. 2013. *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage, California, USA.
- [8] Danielly de Paula and Kathryn Cormican. 2016. Understanding Design Thinking in Desing Studies (2006 - 2015): A Systematic Mapping Study. In *Proceedings of the International Design Conference*. ACM, Aarhus, Denmark, 57–66.
- [9] Jennifer Ferreira, Helen Sharp, and Hugh Robinson. 2011. User experience design and agile development: Managing cooperation through articulation work. *Softw., Pract. Exper.* 41 (08 2011), 963–974.
- [10] Donald Firesmith. 2007. Common Requirements Problems, Their Negative Consequences, and the Industry Best Practices to Help Solve Them. *Journal of Object Technology* 6, 1 (2007), 17–33.
- [11] Irit Hadar, Pnina Soffer, and Keren Kenzi. 2014. The role of domain knowledge in requirements elicitation via interviews: an exploratory study. *Requirements Engineering* 19, 2 (2014), 143–159.
- [12] Jennifer Hehn, Daniel Mendez, Falk Uebernickel, Walter Brenner, and Manfred Broy. 2020. On Integrating Design Thinking for Human-Centered Requirements Engineering. *IEEE Software* 37, 2 (2020), 25–31.
- [13] Jennifer Hehn and Falk Uebernickel. 2018. The Use of Design Thinking for Requirements Engineering - An Ongoing Case Study in the Field of Innovative Software-Intensive Systems. In *Proceedings of the International Requirements Engineering Conference*.
- [14] Lena Karlsson, Åsa G. Dahlstedt, Johan Natt och Dag, Björn Regnell, and Anne Persson. 2002. Challenges in Market-Driven Requirements Engineering - an Industrial Interview Study. In *Proceedings of the International Workshop on Requirements Engineering: Foundation for Software Quality*. 37–49.
- [15] Barbara Kitchenham and Shari Lawrence Pfleeger. 2002. Principles of Survey Research Part 4: Questionnaire Evaluation. *Software Engineering Notes, New York, USA* (2002), 20–23.
- [16] Gerald Kotonya and Ian Sommerville. 1998. *Requirements Engineering - Processes and Techniques* (1st ed.). John Wiley & Sons, New Jersey, USA.
- [17] Klaus Krippendorff. 2018. *Content Analysis: An Introduction to Its Methodology*. Sage, New York, USA.
- [18] Lassi Liikkanen, Miko Laakso, and Tua Björklund. 2011. Foundations for Studying Creative Design Practices. In *Proceedings of the Conference on Creativity and Innovation in Design*. ACM, 309–315.
- [19] Tilmann Lindberg, Christoph Meinel, and Ralf Wagner. 2011. *Design Thinking: A Fruitful Concept for IT Development?* Springer, Berlin, Heidelberg, 3–18.
- [20] Percival Lucena, Alan Braz, Adilson Chicoria, and Leonardo Tizzei. 2016. IBM Design Thinking Software Development Framework. In *Proceedings of the Brazilian Workshop on Agile Methods*. Springer, Curitiba, Brazil, 98–109.
- [21] Tobias Luedeke, Christian Köhler, Jan Conrad, Michael Grashiller, Andreas Sailer, and Michael Vielhaber. 2018. Cyber-Physical Systems/Property-Driven Design in the context of Design Thinking and Agile Development of Cyber-Physical Systems: Use Cases and Methodology. In *Proceedings of the NordDesign Conference*. Linköping, Sweden, 1–24.
- [22] Hugo Martins, Antônio Junior, Edna Canedo, Ricardo Kosloski, Roberto Paldês, and Edgard Oliveira. 2019. Design Thinking: Challenges for Software Requirements Elicitation. *Information* 10 (2019), 371.
- [23] David Morgan. 1997. *Focus Groups as Qualitative Research*. SAGE Publications, California, USA.
- [24] Hasso Plattner, Christoph Meinel, and Larry Leifer. 2010. *Design Thinking: Understand - Improve - Apply*. Springer, Berlin, Germany.
- [25] WMD Ruchira Prasad, GIUS Perera, KV Jeeva Padmini, and HMN Dilum Bandara. 2018. Adopting Design Thinking Practices to Satisfy Customer Expectations in Agile Practices: A Case from Sri Lankan Software Development Industry. In *Proceedings of the Moratuwa Engineering Research Conference*. 471–476.
- [26] Matheus Prestes, Rafael Parizi, Sabrina Marczak, and Tayana Conte. 2020. *On the Use of Design Thinking: A Survey of the Brazilian Agile Software Development Community*. International Conference on Agile Software Development, 73–86.
- [27] Ingo Rauth, Lisa Carlgren, and Maria Elmquist. 2014. *Making It Happen: Legitimizing Design Thinking in Large Organizations*. John Wiley & Sons, New Jersey, USA.
- [28] Janice Singer, Susan E. Sim, and Timothy C. Lethbridge. 2008. *Software Engineering Data Collection for Field Studies*. Springer, 9–34.
- [29] Ian Sommerville. 2010, 9th ed. *Software Engineering*. Addison-Wesley, Harlow, England, 792 pages.
- [30] Versione. 2015. *State of Agile Survey*. Technical Report 9. VersiOne Agile Made Easier.
- [31] Christophe Vetterli, Walter Brenner, Falk Uebernickel, and Charles Petrie. 2013. From Palaces to Yurts: Why Requirements Engineering Needs Design Thinking. *IEEE* (2013), 91–94.
- [32] Lauren Weigel. 2015. *Design Thinking to Bridge Research and Concept Design*. John Wiley & Sons, Ltd, 59–70.
- [33] Didar Zowghi and Chad Coulin. 2005. *Requirements Elicitation: A Survey of Techniques, Approaches*. Springer, New Jersey, USA. 19–46 pages.