

# On the Understanding of the Benefits and Challenges of DT Adoption in Software Development: a Cross-data Analysis

Gabriel Kryvoruchca<sup>1</sup>, Rafael Parizi<sup>1</sup>, Lauriane Correa<sup>1</sup>, Sabrina Marczak<sup>1</sup>

<sup>1</sup>MunDDoS Research Group – School of Technology  
Pontifícia Universidade Católica do Rio Grande do Sul - PUCRS  
Porto Alegre, RS, Brazil

gabriel.kryvoruchca@acad.pucrs.br  
{rafael.parizi, lauriane.pereira}@edu.pucrs.br  
sabrina.marczak@pucrs.br

**Abstract.** *Software companies have been using Design Thinking (DT) to support software development, fostering innovative software features and products. However, there is not much knowledge of what matters for the application of DT being successful. In a previous paper, we investigated how does the adoption of DT in software development takes place in a global Information Technology company focusing on the perceived benefits and challenges. We interviewed 16 professionals in this case study. This extended article further investigates the perceived benefits and challenges of adopting DT in software development. We performed a cross-analysis on data we collected in 2 additional studies: a Survey with 158 IT professionals and a focus-group-based study with 39 IT professionals. Therefore, in this extended article, we analyzed 213 Brazilian professionals' perceptions of the benefits and challenges of using DT in software development. Our analysis compares the benefits and challenges of adopting DT by ORG with those we collected from other professionals', serving as a guide for practitioners on the use of DT in software development.*

## 1. Introduction

Information technology (IT) companies want to deliver software products in less time with higher-quality [Subih et al. 2019]. Putting the user at the center of the software development process has been pointed out for years as the key to success [Luedeke et al. 2018]. It has been argued that Design Thinking (DT) is relevant in this attempt to better establish user-centric activities to support the understanding of user needs and to develop a fit solution [Hehn et al. 2020].

Over the years, DT has received more attention in software development [Levy and Huli 2019]. DT has been adopting by IT companies as a problem-solving approach, fostering problem exploration, multidisciplinary team collaboration, and promoting the users' engagement [Alhazmi and Huang 2020]. DT helps boost Requirement Engineering (RE) activities. It is easy-in integrated into Agile methods to identify users' needs and to propose innovative solutions, frequent deliveries, constant feedback, and quick reaction to changes [Magare et al. 2020].

The use of DT to aid software development activities fosters the development of human-centered solutions more effectively and, therefore, it is worthy of knowing in-

depth about how organizations and its professionals have adopted DT for their activities [Hehn and Uebernickel 2018]. Therefore, this extended article furthers our investigation of the perceived benefits and challenges of adopting DT in software development. We perform a cross-data analysis comparing what we originally collected in a global IT company (here called ORG) with 2 other studies we performed on the topic: a Survey [Prestes et al. 2020] and a Focus Group [Pereira et al. 2021].

Thus, in this article we analyze data collected with 213 Brazilian professionals who use DT in software development. We collected data using 3 instruments: (i) an interview-based data collection in a Case Study in ORG with 16 IT professionals (our original paper), (ii) a questionnaire-based data collection in a Survey study with 158 IT professionals, and (iii) a Focus Group-based data collection with 39 IT professionals. Therefore, we posed our research question: “*Are the perceived benefits and challenges at ORG also perceived by other IT professionals on the DT adoption in software development?*”. Our goal is to compile the perceived benefits and challenges of adopting DT in software development, comparing those we identified at ORG with the benefits and challenges we collected from the other empirical studies. Also, we aim to support professionals on adopting DT, showing the benefits and challenges to adopting DT.

The remainder of this article is structured as follows: Section 2 presents DT in software development and the related work. Section 3 describes the research method we used. Section 4 reports on the results of the cross-analysis study. Section 5 concludes with a summary of this article and future directions.

## **2. Background and Related Work**

Design Thinking has gained recognition as an approach to problem-solving that relies on interdisciplinary teamwork, exploration of human needs, rapid prototyping and interactive learning cycles in the earlier stages of product, service and system development processes [Brown 2008]. Design Thinking proposes to assist software development by supporting the understanding of the users needs [Vetterli et al. 2013].

Recent researches have investigated the use of DT in software development activities. Lucena et al. (2016) conducted a Survey to identify how IBM adopts DT. The study reports that DT contributes by boosting agile software development activities and supporting better results. Jensen, Lozano and Steinert (2016) conducted a Case Study with professionals at SAP. The study points out that DT is responsible for providing an interactive development, integrating both the development team and users. Also, the authors mention DT supports the team to gain a holistic problem overview, involving the users and customers on the understanding of the product’s context and purpose.

De Paula, Amancio and Flores (2020) report their experiences using a light version of DT at IBM. IBM’s executives challenged the authors for applying DT taking into account time and resource constraints. According to the authors, the experience of the light DT version was successful since DT adds value to the product, to the project, to the involved people, and to the whole organization. However, the authors identified as challenges by adopting DT that participants already have a previously established solution and that many of the ideas generated during DT workshops are not put into practice.

Martins et al. (2019) conducted a Case Study in a Brazilian Government IT department. The authors applied DT techniques such as brainstorming and paper prototyping for

**Table 1. Participant's profile**

Role*	Years of experience in software development (avg)			Years of experience in DT (avg)			Number of participants				
	Case study	Survey	Focus Group	Case study	Survey	Focus Group	Case study	Survey	Focus Group	Total	
Developer	8.3	3.2	5.2	2.8	2.0	2.0	04	58	05	67	
Facilitator	x	2.9	5.7	x	2.5	2.8	x	27	06	33	
Designer	x	3.1	3.6	x	2.2	5.1	x	21	18	39	
IT/Business/Other	6.8	3.3	5.0	3.8	2.3	4.7	12	52	10	74	
							Total	16	158	39	<b>213</b>

investigating the challenges on the use of DT for requirements engineering. As a result, the study reports that DT contributed to the participation of users/stakeholders, requirements definition, requirements specification, requirements validation, project schedule estimation, and activities planning. On the other hand, the study indicated that there is no full evidence that DT provides attention to non-functional requirements, to deal with change of requirements, to the cost and time estimation, and to perform usability tests.

### 3. Research Method

This extended article furthers our investigation on the perceived benefits and challenges of DT adoption in software development. We collected 213 IT professionals' perceptions cross-analyzing 3 distinct studies: an interview-based Case Study at ORG (our original paper), a Survey, and a Focus Group. Therefore, we posed the main research question for the current article: *“Are the perceived benefits and challenges at ORG also perceived by other IT professionals on the DT adoption in software development?”*

This section introduces the studies' setups and a summary of the participants' profiles of each study. We analyze data collected with 213 IT professionals focusing on the perceived benefits and challenges of DT adoption in software development. Table 1 shows the IT professional's information such as role, experience in software development, and experience on the use of DT in software development. We grouped the participants into 4 categories considering the professional's roles based on their self-definitions:

- **Developers:** professionals who work with development tasks. For instance, we included in this category developers, agile coaches, scrum masters, etc;
- **Designers:** professionals who work with design activities. For instance, we included in this category UX Designers, Design Managers, etc;
- **Facilitators:** professionals who facilitate DT in software development. For instance, we included in this category DT Thinkers, DT Facilitators, etc;
- **IT/Business/Other:** professionals who work in software companies that we did not include in the other categories. For instance, we included in this category professionals such as Chief Executive Officers, Marketing Analysts, Manager, etc.

### **3.1. Studies' Setup and Participants Selection**

#### **3.1.1. Interview-based Case Study at ORG**

Our original study [Kryvoruchca et al. 2020] reports an interview-based Case Study performed at ORG. ORG is a global IT company that counts with over 10,000 employees located in sites around the world. In Brazil, ORG counts with more than 2,000 employees. ORG has been using DT based on the D-school model to develop software solutions.

In our study, we initially observed a DT session for 2 hours to understand how DT is applied at ORG. Then, we invited and interviewed 16 IT professionals who work at ORG's Brazil site<sup>1</sup>. We conducted semi-structured interviews following the guidelines suggested by Kitchenham and Pfleeger (2002). We started by creating an interview script. A senior researcher, who has experience in software development, evaluated the interview script. Once the interview script was approved, we started the interviews. Next, we transcribed the interviews and analyzed the transcribed data.

Before starting the interviews, we sent a consent form for each professional who accepted our invitation. Then, the first author interviewed the professionals in a dedicated room at ORG. Each interview took an average of one-hour long. We registered the interviews in notes and in audio recordings. After we concluded all interviews, we analyzed the data using data analysis procedures proposed by Krippendorff (2018). Details of our interview-based Case Study are available in Kryvoruchca et al. (2020).

#### **3.1.2. Survey with IT Professionals**

In our second study, we analyze an exploratory Survey we developed to capture the understanding of the Brazilian software development community on the use of DT, as reported in Prestes et al. (2020). We run the Survey between November 2019 and January 2020. For this extended article, we considered only the Survey results that are scope of this article: the benefits and challenges.

We followed the guidelines for Surveys in the Software Engineering field proposed by Kitchenham et al. (2002). We designed a questionnaire using Qualtrics tool<sup>2</sup>. Next, a senior researcher with experience in Software Engineering reviewed the questions we posed in the questionnaire. We invited professionals using the LinkedIn virtual network. We sent the Survey to 466 professionals who work with DT in software development. Our Survey was answered by 158 professionals. The response rate was 33,9%.

#### **3.1.3. Focus Group based Study with IT Professionals**

In our third study, we analyze a Focus Group study we conducted to collect perceptions of IT professionals who use DT to support software development activities. We performed the Focus Group in 7 sessions (5 sessions were co-localized and 2 sessions were remote).

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<sup>1</sup>ORG classifies those who use DT in software activities in DT Coaches and DT participants. DT coaches are professionals who received formal training about DT, while DT participants are those professionals that participate in DT sessions, usually conducted by DT coaches.

<sup>2</sup><http://www.qualtrics.com>

A moderator with more than 5 years of experience in DT and more than 11 years of experience in the software industry conducted the sessions. The sessions were held between February 2019 and April 2019. Each session counted with an average of 6 IT professionals, exploring a multidisciplinary set of professionals' roles.

We invited professionals from companies placed at TECNOPUC (Technology Park located at PUCRS University) and online groups in LinkedIn network. Some professionals were invited by those that have accepted our invitation, as a snowballing effect. In total, 39 professionals participated in our Focus Group. The focus-group sessions had an average duration time of 88 minutes-long. We recorded all sessions using video and audio. We also took notes of the discussions. At the end of all sessions, we transcribed all audio recordings and used the video recordings to support the understanding of the audio transcriptions. Then, we analyzed the data using data analysis procedures proposed by Krippendorff (2018). The Focus Group study is detailed in [Pereira et al. 2021].

#### **4. Results and Discussions**

This section presents the results of our 3 studies, including a Case Study at ORG (our original paper), a Survey, and a Focus Group with IT professionals. In this extended article, our goal is to compare what are the perceived benefits and challenges of DT adoption in software development at ORG with those we collected on the other empirical studies.

We performed a data analysis based on the content analysis procedures proposed by Krippendorff (2018). We identified 6 benefits of adopting DT in software development from the Case Study, 11 benefits from the Survey, and 9 benefits from the Focus Group. We also identified 4 challenges to adopting DT at ORG from the Case Study, 16 challenges from the Survey and 5 challenges from the Focus Group. Then, we performed a cross-data analysis grouping the benefits and challenges of adopting DT in software development by similarity. The categories were discussed and verified by other researchers.

Table 2 shows the benefits of DT adoption that we identified in each of the studies and the categories we created to group the benefits according to their similarities. We identified a consensus between the ORG's professionals with other IT professionals that DT collaborates with creativity, helps to produce better solutions, to optimize cost and time, users' collaboration, user-centered perspective, problem identification and empathy.

Professionals at ORG have used DT as a strategy for product innovation and process improvement. They mentioned that DT collaborates with the production of better products ("Creativity", "Better solutions", and "Problem understanding" categories) and that DT helps with the development process by optimizing cost and time and collaboration among team members ("Collaboration" and "Cost and time optimization" categories). DT is also understood as a user-centered approach that allows the development of solutions that meet the real needs of these users ("User-centered" category).

Regarding empathy, which was not explicitly pointed out by ORG professionals as a benefit of adopting DT, as reported in the other studies, ORG professionals understand that DT fosters collaboration with users and that DT is a user-centered approach. Therefore, empathy may be inherent in this understanding as it is used to refer to understanding the problem from DT and exploring collaboration with users ("Collaboration" and "Problem understanding" categories).

**Table 2. Cross-analysis of perceived benefits of DT adoption**

Categories	Case Study	Survey	Focus Group
<b>Creativity</b>	- creativity	- creativity	
<b>Better solutions</b>	- discovery of innovative solutions	- improve requirements definition	- builds better solutions - add value on deliverable
<b>Cost and time optimization</b>	- cost reduction and time optimization	- decrease the time and money spent - decrease time to fail	
<b>Collaboration</b>	- users' collaboration	- foster collaboration - improve communication	- engage people - learning with stakeholders - improves communication
<b>User-centered</b>	- focus on end users	- better requirements	- better requirements - builds a human-centered mindset
<b>Problem understanding</b>	- problem identification	- problem identification - decrease solutions uncertainties - decrease understanding gap risks	- decrease the lack of understanding
<b>Empathy</b>		- fosters empathy	- fosters empathy
Total	6	11	9

**Table 3. Cross-analysis of perceived challenges of adopting DT**

Categories	Case Study @ ORG	Survey	Focus Group
<b>Availability of rooms</b>	- availability of rooms		
<b>Lack of valorization</b>	- lack of valorization	- lack of value - lack of investment of money	- lack of valorization
<b>Lack of enough time to solve the problem</b>	- lack of enough time to solve the problem	- enough time	
<b>Lack of goals' definitions</b>	- lack of goals' definitions	- adapt DT in each context	
<b>Deal with cultural barriers</b>		- need a cultural transformation - low maturity to use DT - resistance to adopt DT	- cultural barriers
<b>Handle with participant's insights</b>		- converge the insights - align stakeholders' expectations	- respect people's insights
<b>Conduct DT sessions</b>		- lack of knowledge - professional with DT experience - adapt DT in each context - use in complex situations	- maintain neutrality
<b>Understand the problem first</b>		- understand the problem first	- pre-designed solutions
<b>Lack of empathy</b>		- lack of empathy	
<b>Lack of viability to build the solution</b>		- lack of viability to build the solution	
Total	4	16	5

Table 3 reports the challenges of adopting DT in software development that we collected with professionals in the 3 studies we conducted. We categorized the challenges to analyze which of them are perceived at ORG and also mentioned by other software development professionals. The results show that at ORG there are fewer challenges pointed out by the professionals for adopting DT if we compare with the other studies. At ORG, the professionals are trained to use DT, which represents an innovation strategy.

Furthermore, in the Survey and in the Focus Group, the professionals represent different companies, where DT may not be established as an innovative approach.

ORG is a company that has been using DT systematically for years. Thus, the challenges represented by the categories “Deal with cultural barriers”, “Conduct DT sessions” and “Lack of viability to build the solution” were not pointed out by ORG’ professionals. We assume that this is because DT is consolidated at the company. Another challenge not mentioned at ORG is Empathy. Empathy has been understood at ORG through collaboration with users and DT perspective as a user-centered approach. In addition, the challenges pointed out by the Survey and Focus Group professionals grouped as “Handle with participant’s insights” and “Understand the problem first” were not mentioned by ORG professionals because DT at ORG is focused on collaboration with users and helps identify the problem.

Challenges pointed out by professionals at ORG such as “Lack of enough time to solve the problem” and “Lack of valorization” are also mentioned in literature. For instance, De Paula, Amancio and Flores (2020) indicate that despite generating various ideas through brainstorming activities, many of these ideas are not put into practice. The authors also mention that exploring the potential of DT is necessary to do a prework analysis and define a clear statement of the problem or business challenge help to face the challenge of lack of goals’ definition.

Professionals at ORG pointed out that room availability is a challenge for DT adoption. This challenge may be related to the fact that the nature of a Case Study fosters understanding a phenomenon in its context, differently of a Survey or a Focus Group. Dobrigkeit and De Paula (2019) mention that availability of rooms and resources are considered DT enablers, that represents a mechanism which collaborates with DT adoption.

## **5. Final Considerations**

This extended article presented a cross-data analysis on the perceived benefits and challenges of DT adoption in software development. We compared data collected in 3 empirical studies, matching the perceived benefits and challenges captured in the Case Study at ORG, a global IT company that we reported in our original paper, with those results we extracted from a Survey and a Focus Group with IT professionals.

We posed as our research question: “*Are the perceived benefits and challenges at ORG also perceived by other IT professionals on the DT adoption in software development?*”. We observed 26 benefits and 26 challenges of adopting DT in software development through the analysis of the results. We empirically extracted data from 213 IT professionals. We performed a cross-data analysis grouping the perceived benefits of adopting DT in 7 categories and grouping the perceived challenges in 10 categories.

The results show that the most of the benefits of adopting DT reported by IT professionals are also perceived at ORG. We perceived that only DT for fostering empathy was not mentioned by the ORG’s professionals, but it may be expressed in by user’s collaboration and problem understanding. All the other benefits perceived by IT professionals are also perceived by professionals from ORG. Regarding the challenges, the availability of rooms was mentioned just by ORG’s professionals. The lack of enough time to solve the problem and the lack of goal’s definition was mentioned at ORG and mentioned

by the professionals who participated in the Survey. Challenges such as dealing with cultural barriers, handling participants' insights, conducting DT sessions, understanding the problem first, lack of empathy and lack of visibility to build solutions were pointed out by IT professionals in the Survey and Focus Group. However, since DT is consolidated at ORG, the professionals did not mention these challenges on the DT adoption.

Our studies have limitations inherent to empirical researches that are also present in this current study. For instance, the professionals' answers can represent their own view of adopting DT and not represent the company's view on the topic. To mitigate that, we invited employees with different expertise, time working in the company, and different company areas. We also compared various studies' results, extracting data for different DT adoption contexts that can determine the results. Another limitation is the lack of detailed context for the Survey data. Although we do know the company and participants' profile, we have not had the chance to ask more on "why" certain responses were provided. This gives us room for future studies now that we have insights from comparing the different datasets.

As future work, we intend to investigate what elements collaborate with IT professionals to overcome the challenges in adopting DT, seeking to help IT professionals to obtain further benefits using DT in software development.

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## References

- Alhazmi, A. and Huang, S. (2020). Integrating Design Thinking into Scrum Framework in the Context of Requirements Engineering Management. In *Proc. of the Int'l Conf. on Computer Science and Software Engineering*, page 33–45, Beijing, China. ACM.
- Brown, T. (2008). Design Thinking. *Harvard Business Review*, 86:84–92.
- de Paula, T. R., Amancio, T. S., and Flores, J. N. (2020). Design Thinking in Industry. *IEEE Software*, 37(02):49–51.
- Dobrigkeit, F., de Paula, D., and Uflacker, M. (2019). InnoDev: A Software Development Methodology Integrating Design Thinking, Scrum and Lean Startup. In *Design Thinking Research*, pages 199–227. Springer.
- Hehn, J., Mendez, D., Uebernickel, F., Brenner, W., and Broy, M. (2020). On Integrating Design Thinking for Human-Centered Requirements Engineering. *IEEE Software*, 37(2):25–31.
- Hehn, J. and Uebernickel, F. (2018). The Use of Design Thinking for Requirements Engineering: An Ongoing Case Study in the Field of Innovative Software-Intensive Systems. In *Proc. of the Int'l Requirements Eng. Conf.*, pages 400–405, Banff, Canada. IEEE.

- Jensen, M. B., Lozano, F., and Steinert, M. (2016). The Origins of Design Thinking and the Relevance in Software Innovation. In *Proceedings of the Conference on Product-Focused Software Process Improvement*, pages 675–678, Trondheim, Norway. Springer.
- Kitchenham, B. and Pfleeger, S. L. (2002). Principles of Survey Research Part 4: Questionnaire Evaluation. *SIGSOFT Software Engineering Notes*, pages 20–23.
- Kitchenham, B. A., Pfleeger, S. L., Pickard, L. M., Jones, P. W., Hoaglin, D. C., El Emam, K., and Rosenberg, J. (2002). Preliminary guidelines for empirical research in software engineering. *IEEE Transactions on Software Engineering*, 28(8):721–734.
- Krippendorff, K. (2018). *Content Analysis: An Introduction to Its Methodology*, page 472. Sage, New York, USA.
- Kryvoruchca, G., Corrêa, L., Parizi, R., and Marczak, S. (2020). The Use of Design Thinking in a Global Information Technology Company. In *Anais da Escola Regional de Engenharia de Software*, pages 154–163, Conferência Virtual. SBC.
- Levy, M. and Huli, C. (2019). Design Thinking in a Nutshell for Eliciting Requirements of a Business Process: A Case Study of a Design Thinking Workshop. In *Proc. of the Int'l Requirements Engineering Conf.*, pages 351–356, Jeju Island, South Korea. IEEE.
- Lucena, P., Braz, A., Chicoria, A., and Tizzei, L. (2016). IBM Design Thinking Software Development Framework. In *Proceedings of the Brazilian Workshop on Agile Methods*, pages 98–109, Curitiba, Brazil. Springer.
- Luedeke, T., Köhler, C., Conrad, J., Grashiller, M., Sailer, A., and Vielhaber, M. (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 *Proc. of the NordDesign Conference*, pages 1–24, Linköping, Sweden. Design Society.
- Magare, A., Lamin, M., and Chakrabarti, P. (2020). Inherent Mapping Analysis of Agile Development Methodology Through Design Thinking. In *Proc. of the Int'l Conference on Data Science and Intelligent Applications*, pages 527–534, Gujarat, India. Springer.
- Martins, H., Junior, A., Canedo, E., Kosloski, R., Paldês, R., and Oliveira, E. (2019). Design Thinking: Challenges for Software Requirements Elicitation. *Information*, 10:371.
- Pereira, L., Parizi, R., Prestes, M., Marczak, S., and Conte, T. (2021). Towards an Understanding of Benefits and Challenges in the Use of Design Thinking in Requirements Engineering. In *Proceedings of the Symposium on Applied Computing*, Virtual Event, Republic of Korea. ACM.
- Prestes, M., Parizi, R., Marczak, S., and Conte, T. (2020). On the Use of Design Thinking: A Survey of the Brazilian Agile Software Development Community. In *Proc. of the Int'l Conf. on Agile Software Development*, pages 73–86, Copenhagen, Denmark. Springer.
- Subih, M. A., Malik, B. H., Mazhar, I., Yousaf, A., Sabir, M. U., Wakeel, T., Izaz-ul Hassan, W. A., Bilal-bin Ijaz, M. S., and Nawaz11, H. (2019). Comparison of Agile Method and Scrum Method with Software Quality Affecting Factors. *International Journal of Advanced Computer Science and Applications*, 10(5):531–535.
- Vetterli, C., Brenner, W., Uebernickel, F., and Petrie, C. (2013). From Palaces to Yurts: Why Requirements Engineering Needs Design Thinking. *IEEE Internet Computing*, pages 91–94.