Towards a Data-Driven Requirements Elicitation Tool through the Lens of Design Thinking

José Cezar de Souza Filho, Walter Takashi Nakamura, Lígia Márcia Teixeira, Rógenis Pereira da Silva, Bruno Freitas Gadelha and Tayana Uchôa Conte
Institute of Computing (IComp), Federal University of Amazonas, UFAM, Manaus, Brazil

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Abstract: Data-Driven Requirements Engineering (DDRE) proposes that software requirements development goes beyond the application of traditional elicitation techniques (*e.g.*, interviews and questionnaires) by considering other sources of data, such as user reviews available on app stores, social networks, and forums. While many studies are looking for requirements mining and automatic classification through machine learning, information retrieval, and natural language processing algorithms, few studies investigate how to support software practitioners who will use this knowledge in practice, for instance, through tools to support the process. In this context, Design Thinking (DT) emerged as a promising approach to design user-centered solutions to this problem. Thus, in this paper, we conducted an exploratory study to investigate how DT benefits the development of a data-driven requirements elicitation tool. To do so, we applied the Double Diamond process, having in mind Brown's DT Cycles, supported by a set of DT techniques. Our results indicate that DT techniques can be integrated into the development process, allowing a better understanding of the problem and supporting the development of user-centered solutions. We provide the benefits and drawbacks of adopting DT as a toolbox in the context of DDRE tools.

1 INTRODUCTION

Advances in mobile technology led to a data increase on the real use of software. Nowadays, online stores, such as Google Play and Apple's App Store, allow users to report their experiences when using the applications by posting reviews in the platform. From developers' perspective, these reviews are a valuable source of information that can support the identification of missing features, bugs, improvement suggestions, and experience reports (Guzman and Maalej, 2014), as well as a set of requirements that can drive future releases (Carreño and Winbladh, 2013).

Traditionally, Requirements Engineering (RE) involves the use of techniques such as interviews, questionnaires, focus groups, and workshops. However, RE has been changing the approaches to consider other sources, such as reviews from social networks, forums, and user reviews (Maalej et al., 2015), leading to a paradigm shift known as Data-Driven Requirements Engineering (DDRE).

Some researchers have been working on the topic, for example, investigating algorithmic solutions on how to automate requirements mining and classification by applying different machine learning, information retrieval, and natural language processing algorithms (Maalej et al., 2015; Lu and Liang, 2017). However, few efforts have been made to understand how to support software practitioners who will use this knowledge in practice, for instance, through tools. Therefore, we need to move forward in investigating practitioners' needs and eliciting requirements to develop tools that support the DDRE process. To support the development of such tools, we can use Design Thinking (DT), a discipline that uses empathy, collaboration, and experimentalism to understand users' needs and design solutions to a certain problem, focusing on achieving innovation (Brown, 2008).

This paper presents an exploratory study to investigate how DT can benefit the development of a data-driven requirements elicitation tool. To do so, we applied the Double Diamond process (Design Council, 2015), having in mind Brown's DT Cycles (Brown, 2008), supported by a set of DT techniques. With this work, we provide the benefits and drawbacks of adopting DT as a toolbox in the context of DDRE tools, which can be useful for practitioners in selecting DT techniques to develop future software tools.

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2 DESIGN THINKING

Design Thinking is a discipline that adopts methods and designers' sensibility to develop people's needs-oriented products, combining what is technologically feasible and business strategy to generate customer value and market opportunity (Brown, 2008), and has been investigated by recent works on RE. For instance, Canedo et al. (2020) observed that DT contributes to the improvement of requirements elicitation process and that it allows, through prototyping, the identification of errors in requirements understanding prior to implementation. Also, Hehn et al. (2019) presented approaches for tailoring and integrating DT and RE.

There are several DT processes in the literature. One of the most known is Brown's Design Thinking Cycles (Brown, 2008), composed of three phases: *inspiration* puts designers in touch with circumstances (*e.g.*, a problem, an opportunity, or both) that motivate the search for solutions; *ideation* is the phase of generating, developing, and testing ideas that can result in solutions; and *implementation* is the process of putting a viable idea on the market.

Another process is named Double Diamond (Design Council, 2015), represented by two diamonds. The first diamond explores a circumstance in a broader or deeper way (divergent thinking) and has two steps: *discover* involves collecting information and insights from people affected by the circumstance to gain an initial problem understanding; and *define* uses the insights obtained in the previous step to achieve a deep problem understanding, identifying the needs and opportunities to be solved. The second diamond focuses on taking actions to problem-solving (convergent thinking) and has two other steps: *develop*, in which designers use the data collected and work collaboratively to build different solutions for the problem; and *deliver*, the time to validate the proposed solutions, discarding those that did not work and improving the most appropriate ones, *i.e.*, it is the moment to converge the solution to be delivered.

3 METHODOLOGY

In this paper, we investigate how DT benefits the development of a data-driven requirements elicitation tool to support the automation of the requirements elicitation process following the DDRE paradigm. The tool, called Mining Reviews, mines user reviews from a mobile application available in app stores, analyzes them and summarizes the results by presenting the most frequent terms mentioned by users and their respective reviews, which requirements engineers can use to proceed with requirements' development and management. The tool can contribute to improving existing applications and creating new ones that seek to solve the problems and gaps in competing applications according to users' feedback.

To better understand stakeholders' needs to develop this tool, we applied the Double Diamond process, having in mind Brown's DT Cycles (Section 2), supported by a set of DT techniques (Figure 1). From that process, we obtained findings on the benefits and drawbacks of DT techniques applied, guided by two questions: (i) how did each DT technique contribute to the tool development? and, (ii) if and how did each DT technique cause the need to modify/improve the artifacts generated by the other techniques?

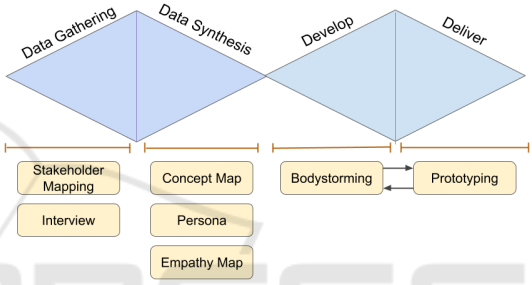

Figure 1: DT process and selected techniques inspired by Design Council (2015).

3.1 DT Techniques Selection

To support techniques selection, we consulted the Design Thinking Assistant for Requirements Elicitation (DTA4RE) tool[1] (Souza et al., 2020). This tool provides an repository about 27 DT techniques categorized by their application in the different phases of the DT process, presenting, for each technique, when to use it, its pros and cons, and other information. We analyzed the techniques suggested for each DT process phase and selected the most appropriate ones according to the applicability to the problem under investigation. In the next subsections, we detail each technique selected.

3.2 Data Gathering Techniques

Stakeholder Map. The first step to develop a product is to identify the key stakeholders that affect or are affected by the project development. This information may not be clear during initial-stage projects, thus we needed a technique to support us in this process. The Stakeholder Map is a technique that pro-

[1] https://sites.google.com/site/dta4reassistant/

vides a visual representation of the groups that are involved in a project, making it possible to analyze and map their relationships (Stickdorn et al., 2011). We used a model that helps prioritizing the stakeholders according to their influence and interest in the project based on Mendelow (1981). Influence indicates the power degree that a stakeholder has to hinder or advance the project. Interest indicates how interested the stakeholder is in what is being developed.

Interviews. There are different types of interviews, such as unstructured, structured, and semi-structured. We conducted semi-structured interviews through a set of predefined questions, in which the interviewer has the flexibility to guide the conversation according to the participant's answers to obtain information of interest (Fontana and Frey, 1994). It can be conducted through online meetings, being suitable to the context of the worldwide COVID-19 pandemic scenario. Before starting the interviews, the participants signed an online consent form, stating that the participants' data would be treated anonymously, and we would not publish any sensitive information.

We carried out the interviews through Google Meet platform[2] with three participants from the group identified in the Stakeholder Map as having high interest in the project: a project manager, a software tester, and a software developer. They work on industry projects developing mobile applications and analyze user reviews to identify potential improvements for those applications. We asked questions (available in our technical report[3]) related to their main activities, the need for analyzing user reviews, and the main challenges involved in this process. We also asked their perceptions and expectations towards a tool that could support their work.

3.3 Data Synthesis Techniques

Concept Map. It is a diagram that depicts suggested relationships between concepts by representing ideas and information as boxes that are connected with labeled arrows, often in a downward-branching hierarchical structure (Novak and Cañas, 2006). We chose this method because it allows having a broad view of the project and of the relationship between each idea and information. First, we had a meeting at Google Meet platform to discuss what would be the best way to represent the ideas. Then, to build the concept map, we used a web application called Lucidchart[4], which allowed us to work collaboratively.

[2]http://meet.google.com

[3]https://doi.org/10.6084/m9.figshare.14044151.v3

[4]http://www.lucidchart.com

Personas. Are a hypothetical representation of users that provides an understanding of their characteristics, needs, and goals, which can be used to guide the development process (Castro et al., 2008). We used this technique to have a better understanding of our target group of stakeholders.

Personas were created based on the Personas Empathy Map (PATHY) technique (Ferreira et al., 2018), which provides a template with guiding questions that help describe and create the persona, based, for instance, on his/her experience with technology, needs, and problems. As we only needed to know more about who the persona is, we selected only the items in the 'who' field. We filled the template to create two personas: one male and one female. To avoid creating empathy with a persona with the same gender as its creator, a male researcher was responsible to create the female persona and vice versa.

Empathy Map. This method allows externalizing the knowledge about users and supporting the decision-making process. More than just demographic characteristics, it allows understanding customer's environment, behavior, aspiration, and concerns (Ferreira et al., 2015; Gray et al., 2010) to gain empathy with a specific person (Osterwalder and Pigneur, 2010). With this method, we aimed to decipher the stakeholders' minds by putting ourselves in their shoes and to go beyond the creation of simple personas by giving them life through their pains and needs. we used the template presented by Osterwalder and Pigneur (2010), which is composed of 6 quadrants that address what they do, see, hear, think and feel, as well as their pains and gains.

3.4 Develop Technique

Bodystorming. It is a type of brainstorming that involves active staging with simple prototypes (Hanington and Martin, 2012), *i.e.*, the researchers put themselves in the stakeholders' shoes, staging situations similar to what happens in their daily lives. We employed it to understand better how the use of our tool could help our stakeholders. To perform customer experimentation with our tool, we followed two steps: Script Creation and Bodystorming Video.

In *Script Creation*, we defined two scenarios, one for each stakeholder represented by the personas we created in the Data Synthesis phase. In these scenarios, the stakeholders would need to look among several reviews to identify relevant features to be improved, created, or removed. After creating and discussing the scripts, we followed to the *Bodystorming Video* step to simulate the meetings of stakeholder 1 with his bosses and stakeholder 2 with her friends

through a video call.

At a given moment in the scenarios, we realized that the stakeholders would need to interact with our tool and provide feedback. To create a visual representation of the tool, we applied Prototyping (Section 3.5). Following the iterative nature of the DT process, we performed the Script Creation before Prototyping to understand the interaction scenarios better and gain insights. Thus, we performed the Script Creation and Bodystorming Video until the scenes where the stakeholders interact with the tool. Then, we developed the prototypes and went back to the bodystorming process to finish the scripts and recordings.

3.5 Deliver Technique

Prototyping. It allows validating the ideas produced and can occur continuously and parallel to the previous phases. In this technique, a tangible artifact is created to develop and test the ideas with project teams, clients, and end-users (Hanington and Martin, 2012). In this step, we, as a team, discussed how the interface would look like and how we would show the results to the stakeholders. To do so, we designed a high-fidelity prototype developed in HTML and CSS3.

4 RESULTS

In this section, we present the results and artifacts created with the techniques in each DT phase.

4.1 1st Diamond: Divergent Thinking

Stakeholder Map. Initially, we had a limited view of the stakeholders. Some team members did not recognize software practitioners as end-users of the tool, but only the end-users of mobile applications from which the reviews will be extracted. This technique allowed us, as a team, to identify that we have a specific case of end-users since they will use the tool as part of the development of new software products, going beyond the daily use of common software. It also allowed us to identify stakeholders that we did not think of until then (*e.g.*, application investors).

Through a visual representation, we could analyze the relationship between influence and interest of the people involved in the project. As a result, we identified four different stakeholder groups (Figure 2).

1. *Application Investors:* a group of people who will provide financial support to the project. As investors, they have their feet on the ground and are cautious to spend their money. Usually, they seek to invest in business opportunities instead of focusing on the details of the application. In this sense, they are the stakeholders with low interest and influence in the project, as our tool will not benefit them directly.

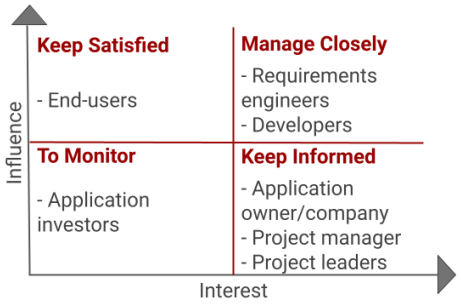

Figure 2: Stakeholder map.

2. *Requirements Engineers and Developers:* the stakeholders that will use our tool and will be directly benefited by the project. For this reason, they have high interest and high influence in the project, being necessary to always keep them informed through active communication to evaluate whether the tool is meeting their needs.
3. *End-users:* typically, mobile application end-users are the main target of requirements engineers and developers, which makes them very influential in the project. By contrast, our tool will not benefit them directly, as it is being designed for software practitioners. Instead, they will benefit from the improvements brought by developers and requirements engineers for the mobile application through the use of our tool. Thus, they have high influence but low interest in our project.
4. *Application Owner/Company, Project Leaders, and Managers:* as their teams will use our tool to improve the company's products, their interest in the project is high. However, they have low influence, as they will not use our tool directly.

Based on the results, we decided to focus on the two groups with more interest in our project: i) developers and requirements engineers; and ii) project leaders and managers.

Interviews. The results indicated that the three participants have analyzed user reviews to improve the company's software. The software tester, for instance, stated "*currently, in our project group, it is necessary at a certain time to look at user reviews about our application to see the problems they reported and what we can improve*". This indicates that the companies are aware of the importance of user reviews for software development and evolution.

Regarding the main challenges, two interviewees

pointed out the lack of constructive information in the reviews, which hinders the identification of what aspects of the software to improve or fix. The software tester, for instance, stated "*users sometimes do not make a constructive criticism, they do not tell you what should be improved in the application explicitly*". Two interviewees also pointed out the time required to read and analyze the reviews, which makes a manual analysis unfeasible. The project manager, for instance, stated "*[the problem is the] waste of time reading lines and lines of feedback to transform them into a few lines of technical terms*".

Finally, when asked about the helpfulness of an automated analysis of user reviews and their expectations about a tool designed for this task, all three stakeholders were unanimous in saying that it would contribute a lot to their work, especially to speed up the development process. The software tester, for instance, stated "*this would be very interesting. In addition to showing constructive comments, filtering what we need would be very cool, [i.e., extracting] both negative feedbacks, by which we could improve our application, as well as positive feedbacks. This will greatly automate our work*".

In summary, the results from the interviews revealed that the problem under study is real and relevant. We found that the automation of mining user reviews could help them identifying the main issues and speeding up the development process. It highlights the need for approaches that automate the analysis and provide relevant information for the development team to improve the company's software. Thus, we proceeded to the next step to obtain more information and expand our understanding of the problem.

Concept Map. The concept map helped us to organize, analyze, and understand the concepts of the project. The visual representation (Figure 3) made it easier to have a broad view of the project and identify the relationship between each concept. However, this technique was not so useful to gain insights to improve the project.

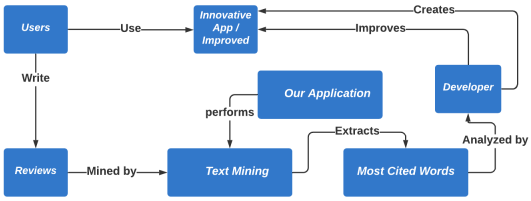

Figure 3: Concept map.

Personas. The creation of the personas allowed us to identify what is the profile of the users we will be dealing with, since some team members were initially unaware of this information. In this way, the technique helped the team to recognize the different needs, experiences, and the stakeholders' behaviors. We created two distinct personas for the group with high priority identified in the Stakeholder Map, focusing on the need to use our tool (Figure 4).

Empathy Map. This technique helped us to create empathy with the stakeholders and think about their needs, feelings, and desires. We built two empathy maps based on existing knowledge and data from the personas created. Figure 5 presents the empathy map for persona 2.

4.2 2nd Diamond: Convergent Thinking

Bodystorming. This technique enable us to represent situations in which we put more attention on understanding the problem than on identifying a solution. The application of bodystorming made it easier to understand and empathize with users by acting in different roles in the interaction within a short period of time. Moreover, it allowed immediate feedback for the ideas generated and provided a more precise understanding of the contextual factors of the project. The scenarios created in the Script Creation step of bodystorming for the stakeholders represented by personas 1 and 2 are available in our technical report.

Prototyping. Finally, we developed a high-fidelity prototype of our tool with basic functionalities. It allowed us to have a more accurate view of what we will be delivering to the stakeholders. From the interviews, we realized the need to summarize the information to be presented by the tool, since the participants considered unfeasible the time necessary to read and analyze the reviews manually. Therefore, we needed to think about the information visualization and the necessary functionalities to prototype the solution. During the prototype development, we noticed that the use of word clouds would be more intuitive to the stakeholders, as it conveys the importance of each term among the others according to their sizes on the screen, instead of presenting an ordered list with the most frequent terms as originally thought.

On the main screen, we decided to show a video to encourage tool usage and a menu where the stakeholder can select the app in which the reviews will be analyzed. Figure 6 presents the developed prototype representing the basic flow of the tool considering, for instance, a food delivery application. After the user of our tool chooses the desired application, the tool mines its user reviews. The data are then analyzed to identify the most frequent terms in the reviews, presented to the user through a word cloud (Figure 6a). When navigating through it, he/she can click on one of the terms to visualize its related reviews (*e.g.*, the

Name:	Carlos Antônio
Age:	30 years
scholarity:	University education
Profession:	Requirements Engineer
How does he describe himself?	He sees himself as a successful person, focused on work and a person who enjoys the presence of friends and family.
What fears and concerns and frustrations does he have? Why?	There are family concerns, such as security and financial stability. There is a strong concern about getting fired.

Name:	Ada Miller
Age:	35 years
Scholarity:	University education
Profession:	Entrepreneur / Developer
How does he describe himself?	Ada sees herself as a mature, responsible, and fearless person, she is a successful and courageous woman, whose life goal is to create her own startup.
What fears and concerns and frustrations does he have? Why?	As her first startup experience, ada has concerns about whether her business will fail.

Figure 4: Left) persona 1 for a requirements engineer; Right) persona 2 for a businesswoman/developer.

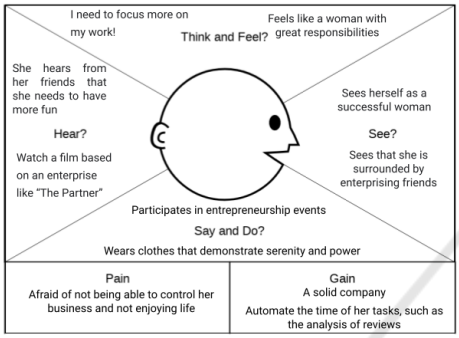

Figure 5: Empathy map for persona 2.

term "service" in Figure 6b) and understand the feedback from the application users better. Finally, the user can download the extracted data and start the mining and analysis for another application.

5 DISCUSSION

The DT techniques provided valuable contributions to the project development. We detail the main findings and lessons learned from each DT phase, as well as implications for practitioners.

5.1 1st Diamond: Divergent Thinking

The **Stakeholder Map** allowed us to have a more comprehensive view of different stakeholder profiles. Through the influence/interest graph, we could identify who would directly or indirectly benefit from the Mining Reviews tool, as well as which of them should be prioritized in the development process. Initially, we had mobile application end-users as stakeholders. By applying this technique, we still considered them as stakeholders but realized that they are not directly benefited by our tool, thus having low interest on it. We identified that our main end-users are practitioners who work directly with application development (*e.g.*, software developers and requirements engineers), as well as other stakeholders (*e.g.*, project leaders, managers, and application investors). By identifying the most influential and interested group of stakeholders, we could focus our efforts on this specific group and plan the next steps accordingly.

Interviews played an important role to understand how the tool would fit into the market. We identified that users' opinion is essential for the stakeholders to identify potential issues and improvement opportunities to increase users' satisfaction. However, they spend a lot of resources and people to streamline the process of adapting their products to their customers' needs and desires, as there is a huge amount of reviews to analyze, most of them not informative. This finding is in accordance with Chen et al. (2014), who identified that only 35.1% of the reviews contained information that can directly support developers improving their software applications. In this sense, the results revealed that the problem under study is real and there is a need to summarize useful information. Thus, the tool proposed can benefit the stakeholders with a more comprehensive view of the application's main issues, which can help them extract and identify the requirements that should be prioritized.

The **Concept Map** helped representing our knowledge about the problem in a structured way. The visual representation allowed a better understanding of the concepts involved in the project and the relationships between them. However, this technique was not so useful to get new insights. It is probably due to the limited amount of data available in this initial stage of the project, which hinders the identification of missing concepts and new relationships that would not be seen before drawing the map.

The **Persona** technique was essential for all team members to share a broad and common view on the different needs, expectations, and stakeholders' behaviors, as this information was not clear to some members. By giving them personalities and concerns, it was possible to understand how our tool would help them, and what improvements we could make to min-

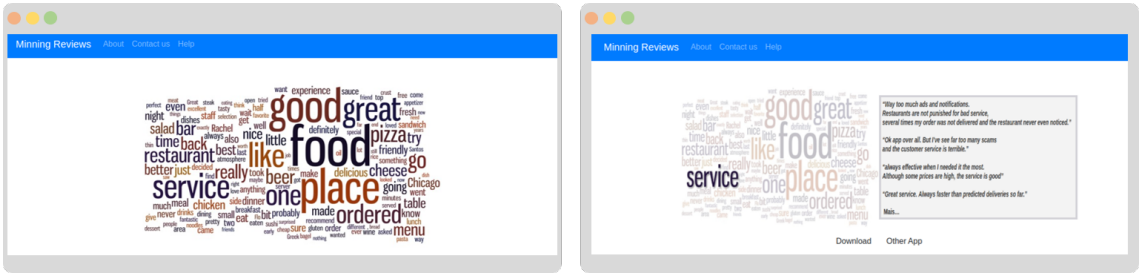

Figure 6: Prototype - a) word cloud as a result of the analysis for a food delivery application; b) viewing related reviews when selecting a word cloud term.

imize their concerns.

Finally, the **Empathy Map** allowed us to go deep into the stakeholders' mind. By analyzing their feelings and behavior, we could understand what our client would think and feel about our tool.

Take Away Message: use the Stakeholder Map to identify stakeholders that had not yet been assumed, especially when the information is scarce. Apply Interview to confirm the relevance of the problem and to know their needs and challenges better. Use Personas to share the same view with your team about who are the users of your application. Apply the Empathy Map to deepen empathy with stakeholders, seeking to understand what they can perceive in your application. These techniques are useful for the initial project steps. The Concept Map is more useful to larger projects, since it may not provide new insights to identify new relationships or entities in project with limited amount of data.

5.2 2nd Diamond: Convergent Thinking

The **Bodystorming** technique provided an innovative way to put ourselves in the stakeholders' shoes by interpreting them and identifying how they can use the tool proposed, which would not be possible through the use of the traditional brainstorming technique. During its application, the idea of using a Web application emerged, as it would be the fastest and most intuitive way for the stakeholders to read and analyze user reviews. Despite its usefulness, we realized that it requires mastering previous techniques. For example, to generate a scenario and a script to simulate what may be a problem and its solution, it is necessary to have a good understanding of the stakeholders, which may only be obtained by employing the techniques presented previously.

Through **Prototyping**, we could identify new solutions to previously seen problems, in addition to new features that we could add to our final product. Before building the prototype, for example, we did not know the best way to present the results to the stakeholders. At first, we thought of providing an ordered list with the most frequent terms. However, we realized that this approach lacks usability, as the user has to scroll down the screen to see more terms. Moreover, a simple list does not convey the relevance of each term. After discussing, we reached a consensus that a word cloud would be much more appealing, informative, and usable to the user, as all terms are presented in the same space with a variety of colors and different sizes according to their frequency, highlighting the relevance of each term.

Take Away Message: use Bodystorming to deepen your understanding of stakeholders by putting yourself in their shoes and acting accordingly. Apply Prototyping to rethink strategies to present summarized information to users.

6 FINAL CONSIDERATIONS

In this paper, we investigated how Design Thinking benefits the development of a data-driven requirements elicitation tool, named Mining Reviews, based on the extraction of user reviews. To do so, we carried out an exploratory study by employing the Double Diamond process (Design Council, 2015) supported by a set of DT techniques that allowed us to deepen our understanding of the problem and trace a path towards a solution that meets the stakeholders' needs. In summary, through DT, we could understand how to help with tooling support people who will use DDRE knowledge in practice.

This study contributes to: (i) understanding the benefits and drawbacks of adopting DT as a toolbox for developing tools to support data-driven requirements engineering; and, (ii) understanding the usefulness of user review analysis for requirements development and the needs and challenges faced in this context by software practitioners, which are being considered in the development of Mining Reviews tool.

Currently, we are developing the Mining Reviews tool based on the solutions identified in this study, in addition to verifying the suitability of the algorithms indicated in the DDRE state-of-the-art. As future perspectives, we intend to analyze the benefits of other DT techniques, such as those that observe stakeholders in their work environment (*e.g.*, Behavioral Archeology and Behavioral Map). We also intend to carry out empirical studies to evaluate the tool's usefulness with practitioners in the industry, as well as in the context of requirements engineering education.

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