Requirements Engineering Challenges and Techniques in Building Chatbots

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Abstract: The proper execution of requirements engineering processes can be decisive for the success of software development and, for chatbots, it is no different. Chatbots have been gaining a lot of space, especially in customer service. Requirements engineering processes for chatbots are as hard to perform as for any other machine-learning system and the conversational nature makes it even harder. Taking this into consideration, in this work we survey chatbot practitioners to unveil the requirements elicitation and documentation techniques they have been using in the industry, besides the challenges they face while going through this process. Responses show that elicitation techniques are not much far from techniques used in other fields, but for documentation techniques that are new forms of documentation such as conversation flows. Moreover, meeting stakeholder's requirements and managing information exchange are their biggest challenges in eliciting and documenting chatbot requirements.

1 INTRODUCTION

AI-based systems are crossing the academic barrier to be increasingly used due to two major factors: the increasing availability of big data and hardware accelerators (Soni et al., 2019). The automation capability of AI services is being especially used in customer services to streamline user service (Khan and Das, 2018) and are increasingly being better accepted by users (Xu et al., 2020). Chatbots are one example of how AI systems are being used in customer services.

Chatbots are intelligent agents powered by machine learning algorithms to mimic human behavior, and users tend to recur to them because of the ease, speed, and convenience of chatting with a chatbot (Brandtzaeg and Følstad, 2017). Since technology geared towards conversational agents is becoming more trustworthy for commercial use, companies have been using chatbots as part of their customer service workforce. Companies recur to this kind of technology for the following main reasons(Zhang et al., 2021): improve customer service experience, reduce cost and resource requirements, and drive digitalization.

Requirements engineering processes for real-world AI-based systems require different approaches than traditional engineering because of their data-driven nature (Kostova et al., 2020). Specifically for machine-learning (ML) systems, requirements engineering processes are challenged by the lack of explainability of ML systems, difficulties in insuring freedom of discrimination, legal constraints over data, and eliciting data requirements (Vogelsang and Borg, 2019).

These challenges are also faced by chatbot practitioners, in addition to the difficulties of meeting requirements related to the conversational nature of chatbots. Although chatbots share the responsibility to engage in a conversation, they can become very different from one another to meet the needs of the brand they represent (Shevat, 2017). This reflects on requirements, which must be of good quality to achieve the business goals with the chatbot. Traditionally, software development teams go from requirements to features. In the context of conversational agents, teams go from requirements to meaningful dialogues. The most valuable delivery for chatbot applications is conversational flows that solve a user's doubt or problem. In fact, if requirements focus firstly on conversation experience, technological architecture will be developed to fit the conversation flow and not the other way around.

In this paper, we have conducted an online-based

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survey with chatbot practitioners to discover the main tools and techniques used in requirements engineering processes in building chatbots. We are also interested in getting to know how practitioners perceive requirements processes in this context and what challenges they face.

2 BACKGROUND

The success of software highly depends on meeting the imposed requirements of stakeholders, which also depends on a good definition of requirements. For that to happen, software engineering comprises requirements engineering. According to (Pressman, 2009), requirements engineering is the spectrum of tasks and techniques that lead to a clear understanding of the requirements, building a bridge to design and construction. There are four main activities in the requirements engineering process (Sommerville, 2010): 1. Feasibility study: investigate if the proposed system is going to be cost-effective and the result determines if the process will continue to the next steps; 2. Elicitation and analysis: work with stakeholders to gather information and use a set of techniques to discover requirements; 3. Specification: the process of writing down requirements in a structured document; and 4. Validation: checks the requirements for realism, consistency, and completeness.

In this work, we focus on elicitation and specification. Elicitation activities are tied to clients and customers because they hold valuable information for discovering requirements. Specification activities are tied to lots of documents that formalize and model decisions of previous activities. We are especially interested in the techniques used by chatbot practitioners when executing these activities besides the challenges they face when doing it.

2.1 Requirements for Chatbots

Chatbot practitioners face additional challenges in chatbot requirements engineering processes since chatbots "have specific UX requirements related to the way the information is presented, the mean of interaction, whether its text, buttons or speech" (Fadhil, 2018). Another challenge of chatbots is designing for open-ended conversations (Brandtzaeg and Følstad, 2018) because conversational requirements must be broad enough to cover all conversation possibilities. Therefore, for this context, there are two new classes of requirements: conversation and data, which are not seen in traditional requirements engineering. Defining data requirements includes defining what the AI

model should detect, such as age groups and language (Akkiraju et al., 2020), and, if relying on open-source data, the filtering criteria for selecting high-quality data (Vogelsang and Borg, 2019). Conversational requirements are all about defining how it communicates with users, including its persona, formality of language, visual aids, and conversation shortcuts.

Having well-defined conversational requirements is important because the customer's quality perceptions are increased if the brand's language is similar to the customer's expectation (Jakic et al., 2017). Therefore, in the development of chatbots, conversations must be seen as the object of design (Følstad and Brandtzæg, 2017). Moreover, diving into knowing your target audience will dictate how your chatbot communicates, since "younger users may be particularly sensitive to playful and emotionally engaging chatbots, whereas older users may be preoccupied with the efficiency and effectiveness of chatbots" (Følstad and Brandtzaeg, 2020).

Another important aspect to consider in the elicitation process is if there are existing sources of data with interactions between the service provider and potential chatbot users, which can be phone calls, emails, chat, social media, and customer self-service (Singh et al., 2019). These sources already contain some requirements for conversation content, especially if the chatbot is being developed to replace one or more of these traditional channels of interaction.

Missing these specific classes of requirements hurt the chatbot's inclusiveness capacity and cause unimaginable damage to brand images. One example is Microsoft's Tay Bot released in 2016, which started to post offensive tweets when learning from user's tweets (Neff and Nagy, 2016). In a research led by The Washington Post, it was revealed that Amazon's and Google's smart speakers work best for white, highly educated, upper-middle-class Americans. (Harwell, 2018). These failures are not uncommon and because of that conversation design has been highlighted by big companies as an important part of chatbot development. Google released its own guide for conversation design (Google, 2021), as well as IBM (IBM, 2021) and Amazon (Amazon, 2021). All of these guides put the user at the center of development. Google's guide has a specific section for gathering requirements that is entirely focused on thinking as the end-users and defining who are they, what their needs are, their context, and their journeys through conversations.

2.2 Related Works

To our knowledge, there are no works addressing specifically requirements engineering processes in building chatbots. However, there are works approaching challenges and techniques in a broader scope that includes chatbots, such as artificial intelligence and machine learning. In (Vogelsang and Borg, 2019), four data scientists are interviewed to understand how machine learning experts approach elicitation, specification, and validation of requirements and expectations. The results show that specific characteristics of machine learning trigger changes in requirements engineering processes, such as new kinds of requirements and the tailoring of traditional approaches.

The work of (Habibullah and Horkoff, 2021) focus on non-functional requirements of machine learning systems. They interview ten engineer practitioners to understand what are the challenges of dealing with non-functional requirements for machine learning in the industry. In the light of their results, they highlight how difficult it is to gather quality attributes for machine learning systems.

(Mendonça et al., 2021) conducted a literature review of requirements engineering processes of agent-oriented software engineering. They focus on discovering how requirements engineering was adapted for the development of multi-agent systems. (Belani et al., 2019) identified the requirements engineering challenges when applied to the development of AI-based complex systems. After gathering challenges presented in related works in the fields of artificial intelligence and software engineering, they propose the RE4AI taxonomy that outlines the challenges posed to requirements engineering towards building AI-based complex systems.

In (Wilhjelm and Younis, 2020), a systematic process is developed for eliciting security requirements of machine learning-based systems. (Ishikawa and Matsuno, 2020) discusses the impact of machine learning uncertainty on existing requirements engineering methods such as goal-oriented requirements elicitation.

3 RESEARCH STRATEGY

In this work, we have investigated how requirements engineering processes are held in the industry of chatbots by surveying Brazilian practitioners. This survey intends to answer the following research questions:

RQ.1 What are the techniques and tools used by practitioners to elicit and document chatbot requirements?

RQ.2 Are the existing tools and techniques of requirements engineering suitable for chatbot development?

RQ.3 How important do practitioners perceive requirements engineering processes in the context of chatbots?

RQ.4 What challenges do practitioners encounter when eliciting and documenting chatbot requirements?

In summary, the research questions are focused on discovering practices and challenges for eliciting and document chatbot requirements. We hypothesize that results will differ from requirements engineering processes from software in general because of the conversational nature of chatbots, which may require different approaches. For answering research questions, we made a survey of 12 questions to share with chatbot practitioners which are transcribed and have their results collected in Section 4.

The survey was online-based and the data collection followed two approaches. The first one was to share the survey link through professional networks and rely on person-to-person disclosure. Since we were looking for practitioners of a niche, we did not expect to collect many responses from this first approach. After this first attempt, we proceeded to find these practitioners through professional profiles that revealed their chatbot background and invited them to answer our survey. We tried to invite Brazilian practitioners from different companies and experiences, to gather broader responses.

4 SURVEY RESPONSES

The survey received a total of 22 responses from chatbot practitioners of different backgrounds. In the next paragraphs, we show results from each question.

Q1. What is the nature of your company? Respondents could choose between "Public" or "Private". 17 (77.3%) were from private companies whereas only 5 (22.7%) were from the public sector. The small number of practitioners from the public sector seems to be circumstantial since chatbots have been widely used in the public sector (Petriv et al., 2019; Adnan et al., 2020; Sun and Medaglia, 2019).

Q2. Which role have you assumed in chatbot projects? Respondents had a set of chatbot-related roles to choose from or the "other" option for the ones that did fit one of them. Developers represented most of the respondents (63.6%), followed by tech leaders (18.2%) and conversation designers (13.6%). One respondent marked the "other" option and justified in

the open field of Q12 that he assumed many of the listed roles for similar periods.

Q3. What software development methodology does your chatbot development team use? The majority of respondents work with the Scrum methodology (68.2%), followed by Kanban (18.2%) and Agile(9.1%). One respondent marked "We have not used a structured methodology".

Q4. What requirements elicitation techniques have your team used to develop chatbots? Figure 1 shows all the techniques marked by practitioners. There were predefined options for them to mark but they could add new options if there were techniques that they have used but were not listed. Brainstorming is by far the most used technique by chatbot practitioners (68.2%).
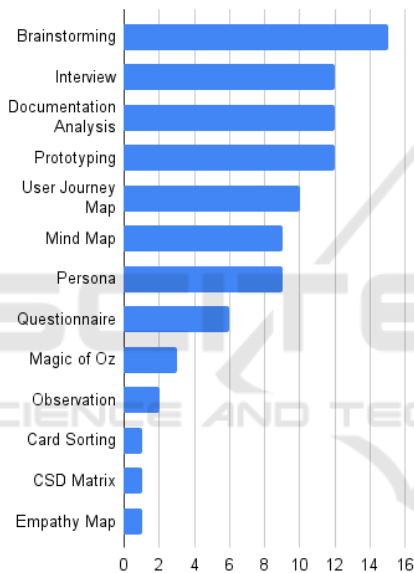

Figure 1: Elicitation techniques used by chatbot practitioners.

Q5. What requirements documentation techniques have your team used to develop chatbots? Figure 2 shows all the techniques marked by practitioners. In accordance with the previous questions, respondents could choose from predefined options or list new ones. The interesting result is that chatbot requirements documentation is mostly done with conversation flows (81.8%), which is a particular option for the field we are surveying in contrast with other software fields. In contrast, user stories are widely used in diverse software fields and are also used by 59.1% of chatbot practitioners. Moreover, user stories are not unfamiliar for agent-driven software architectures as seen in (Wautelet et al., 2016).

Q6. Which tools have your team used to elicit or document chatbot requirements? Since there are
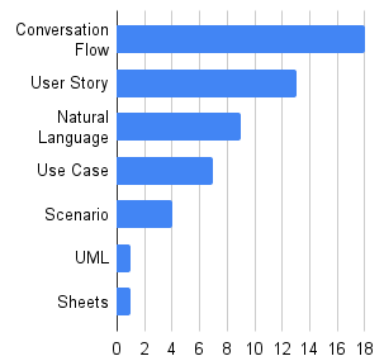

Figure 2: Documentation techniques used by chatbot practitioners.

Table 1: Tools that chatbot practitioners have used in eliciting and documenting chatbot requirements.

Tool	Description	Citations
Bizagi	Tool for modeling business process maps with structured language.	2
Draw.io	Online diagram software with support for various notations and free modeling.	3
Figma	Online UI tool to create, collaborate, prototype, and handoff.	5
Google Forms	Helps in the creation of questionnaires to do surveys and collect data.	1
LucidChart	Online diagram software with support for various notations and free modeling.	1
Microsoft Word	Program for creating natural language documents, commonly known as word processor.	2
Microsoft Excel	Program for organizing and formatting spreadsheets with mathematical formulas and computerization.	3
Miro	Digital whiteboard for distributed teams collaboration.	4
Whimsical	Visual workspace for combining flowcharts, wireframes, sticky notes, mind maps and documents.	1
XMind	Tool dedicated exclusively to creating mind maps.	2

countless tools for supporting the requirements elicitation and documentation, we opted for an open and optional field. We gathered 16 responses that exposed multiple tools used in this process. Table 1 shows tools cited by respondents. They are all very generalist tools that can support many of the techniques listed, even for informal and intermediary documentation.

Q7. In the requirements listing of your chatbot project, were there non-functional requirements? Although 68.24% of practitioners responded "Yes", it is particularly alarming that more than 30% did not have non-functional requirements considering chat-

bots require specific usability and user-experience standards to carry on meaningful conversations.

Q8. Do you think it is necessary to have specific approaches for eliciting and documenting chatbot requirements? Previous questions received scattered responses, especially Q6. This question's results reinforce the need for adaptation in eliciting and documenting chatbot requirements since 77.3% marked "In part, because existing techniques, processes and tools need to be adapted to the context of chatbots". 13.6% responded "Yes" and 9.1% responded "No".

Q9. Do you think that requirements elicitation and documentation processes for chatbots are neglected? Responses were well distributed among options as shown by Figure 3, probably because their companies treat requirements differently. However, responses are more concentrated on the negative spectrum.
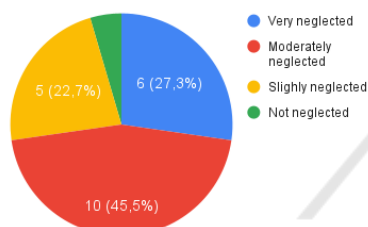

Figure 3: Do you think that requirements elicitation and documentation processes for chatbots are neglected?

Q10. Do you think the non-functional requirements for chatbots are neglected? In comparison with Q9, practitioners think that non-functional requirements are more neglected than the processes in general since responses were: "Very neglected" (36.4%), "Moderately neglected" (50.0%), "Slightly neglected" (13.6%), and "Not neglected" (0%).

Q11. How important is it for you to have a well-structured requirements engineering process for chatbot development? Figure 4 shows the distribution of responses. Although the previous questions seems to indicate that chatbot requirements are not being treated as they should, 77.3% of the respondents see well-structured requirements engineering processes as "Very important". The one respondent that marked "Not important" is a conversation designer. In (Franch et al., 2020), designers are one of the roles who are less favorable towards requirements engineering research, which can corroborate the response from this respondent, although the other two designers considered it "Very important".

Q12. Which challenges have you or your team faced in eliciting or documenting the requirements of a chatbot? This question was optional, open, and received 12 responses. Since open responses leave
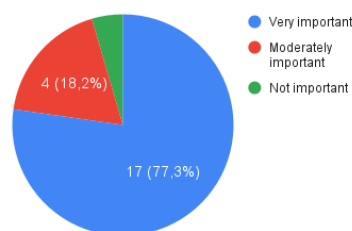

Figure 4: How important is it for you to have a well-structured requirements engineering process for chatbot development?

space for embracing a lot of subjects, we analyzed responses and classified the challenges practitioners cited directly or indirectly in their responses. Table 2 shows this classification.

5 DISCUSSION

When grouping responses by the organization's nature or the practitioner's role, we did not observe any particular phenomenon and responses were very diverse within these groups. This may indicate that techniques and processes are probably more linked to the specific processes of each company, either public or private, than roles or the organization's nature.

Regarding the elicitation techniques used by practitioners, results are not very different from the techniques used in other fields of requirements engineering. Brainstorming, interview, and prototyping appeared as at the top 5 of most used techniques in the context of startups (Rafiq et al., 2017), mobile applications (Dar et al., 2018), IT ukranian professionals (Gobov and Huchenko, 2020), Internet of Things (Lim et al., 2018) and software development in general (Alflen and Prado, 2021).

However, we found some differences in our findings compared with the top techniques in other fields. First, some of our documentation techniques appeared as elicitation techniques, which were user stories and use cases. In works in which this happened, they appeared in the top 5 techniques as well. Moreover, interviews lead most used techniques in all of the 5 works, on the other hand, brainstorming is the most popular technique among chatbot practitioners.

In relation to documentation techniques, user stories are the most used documentation technique in Agile projects (Jarzbowicz and Połocka, 2017; Jarzbowicz and Sitko, 2019). Similarly, as most of our respondents work with Scrum, an Agile methodology, user stories appeared as the second most used technique among them. What stands out in this part of our results is that conversation flows are the most

Table 2: Challenges in eliciting or documenting chatbot requirements that appeared in practitioners' responses.

Challenge	Transcribed excerpts from responses
Difficulties in meeting stakeholders' needs	*"Understanding what the client/user wants [...]"* *"Make a chatbot for the end-user which serves the end-user [...]"* *"The transfer of information between the client and the end user is a big challenge [...]"* *"Problem prioritization, in terms of aligning stakeholders' expectations with actual stakeholders' needs [...]"* *"Clients' objectivity with what they want from the bot [...]"* *"In general, it's the client's understanding. It takes me 1 month to make a bot, and the client takes 2 years to get what he really wanted [...]"* *"Sincerity of users [when testing] [...]"*
Poorly documented requirements	*"Always rework for requirements that were not well defined [...]"* *"Often when the area responsible for eliciting requirements does not have programming knowledge, they miss many important requirements [...] poorly defined acceptance criteria, when they exist."*
Business management	*"POs [Product Owners] that do not actively participate in the process, large companies, areas do not talk."* *"Delay in clients' responses and delay in receiving project details"*
Midway changes in requirements	*"[...] requirements elicitation starts in a way and, when development starts, there are always changes."* *"[...] difficulties caused by clients when changing their minds along the way"* *"[...][poorly defined requirements] end up generating scope change in the middle of development"*
Requirements impossible to be technically implemented	*"[...] is a big challenge, along with the limitations that we find on platforms"* *"[...]Lack of test masks provided by the client. Lack of APIs needed for the feature the client wants to implement in the bot."*
Lack of tools for requirements engineering	*"Lack of proper documentation tools [...]"*
Going from requirements to chatbots	*"Create the context in which the bot would fit and create characters for it."*

used documentation technique. Although this is not alarming considering the nature of chatbots, it is essentially a new technique in requirements engineering. Also, whereas use cases and scenarios are popular in other agile contexts (Jarzbowicz and Połocka, 2017; Jarzbowicz and Sitko, 2019), they are not very used for chatbots.

The fact that chatbot requirements are often documented as conversation flows may justify why respondents used a lot of tools in requirements elicitation and documentation since there is no established way of documenting conversation flows besides prototyping them. Tools cited by practitioners are much more related to elicitation than documentation. This fact is supported by the responses of Q8, in which most of the practitioners affirmed the need to adapt practices to elicit and document chatbot requirements. Using inadequate tools for documenting requirements can especially impair the traceability of requirements, which are critical for the transparency of AI systems (Mora-Cantallops et al., 2021).

The importance of proper documentation tools for requirements is reinforced by one respondent in the open field when questioned about the challenges of chatbot requirements elicitation and documentation. This importance is inferred from the responses of three respondents that have suffered with midway changes in requirements which could be more manageable if there were proper tools to keep requirements traceability, especially in the case of documenting them as conversation flows. Moreover, the challenges reported by respondents focus heavily on human processes and information exchange, which are not very distant from broader contexts, such as agile development. The key challenges in agile requirements engineering are technical dependencies among teams; coordinate decisions; not lose sight of the big picture; continuous management of requirements; work out requirements in cooperation with (end users), and involve stakeholders throughout the whole development process (Schön et al., 2017).

According to our respondents, the biggest challenge in eliciting requirements is meeting stakeholder's needs. This is a challenge in software development in general, but it is an even bigger problem in chatbot development since software qualities in conversation agents are much harder to achieve. Traditional software has to guarantee functionality, usability, reliability, performance, and supportability, whereas chatbots have to guarantee these quality characteristics plus proactivity, conscientiousness, communicability, emotional intelligence, (Chaves and Gerosa, 2021) and other human attributes which are harder to achieve. Lastly, the dispersion in responses

of Q7, Q9, Q10, and Q11 show that requirements generally receive different treatment and are given different importance depending on the team working in it. However, since responses are more concentrated in the negative spectrum of options, they reveal that requirements are probably being neglected by chatbot teams, especially non-functional requirements.

6 THREATS TO VALIDITY

The internal validity of this work is threatened mostly by online-based and unsupervised nature of our survey since we did not have control over the participants when they answering our survey, although we made our contact available for them in case there were any doubts. On the other hand, participants were not pressured to respond by being unsupervised and if they were not compromised in responding the survey they could quit at any time, which makes us believe that the ones that finished responding provided meaningful responses. The external validity is threatened by fact that our survey included only Brazilian practitioners and we could not guarantee that we shared it with professionals of all contexts. Nevertheless, we did reach professionals from many companies and regions from the country albeit they were not obligated to respond the survey since it was only an invitation and we guarantee anonymity in the survey.

7 CONCLUSION

In this work, we surveyed chatbot practitioners to discover what are the techniques and tools they have used and the challenges they face in chatbot requirements elicitation and documentation. We also questioned them about the relevance of requirements in their projects. Our main contribution is to reveal difficulties and the need for adaptation in requirements engineering processes to be addressed in future works.

After gathering results we compared them with the techniques and challenges faced in other software development contexts. In general, the top used techniques are the same used in other software fields. However, interviews are the most used method in other contexts, whereas brainstorming is the most used method by chatbot practitioners. In the context of our research, the fact that stands out is that conversation flows have emerged as a new way of documenting requirements and practitioners are negatively impacted by the lack of tools for this specific purpose.

Lastly, the challenges faced in eliciting and documenting requirements are heavily related to requirements management and information exchange. Also, responses indicate that meeting stakeholders' needs is one of the biggest challenges and we suppose that is due to the fact that chatbots have quality attributes harder to achieve since they are subjective human characteristics.

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