

Towards Inclusive Software: Accessible Questionnaires for Deaf People

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Abstract. *Despite several initiatives to integrate accessibility to the Software Engineering (SE), in practice, little is known about both the participation of people with disabilities in the phases of the software development process and the methods used. Inclusive SE is a challenge and many research opportunities may be identified. In this scenario, our objective was to identify accessibility guidelines for questionnaires, an extensively used technique, aiming at the inclusion of deaf people in many activities of the software development process. We believe initiatives like these guidelines are a step towards the inclusion of deaf people during the whole software development process and could further contribute to the accessibility of software systems.*

1. Introduction

Accessibility refers to the design of products, devices, services, or environments for people with disabilities. It also means that people with disabilities, reduced skills, or situationally induced impairments are able to access, navigate, interact, and contribute to information using different devices, such as web and mobile phones [W3C 2019].

To reach all people, the disability-aware SE is emerging [Nganji and Nggada 2011, Sanchez-Gordon et al. 2019, Ferreira and Bonacin 2014, Bouraoui and Gharbi 2019]. As presented by Leitner et al. [Leitner et al. 2016], the implementation of accessibility within a company is based on many factors, for example, the sector that an organisation works in and social willingness. However, there are few reports describing how SE addresses the participation of stakeholders with disabilities in the phases of the software development process [omitted]. As presented by Menezes and Prikładnicki [Menezes and Prikładnicki 2018] it is possible to observe that practices related to the work environment can contribute to inclusion as well as to organizational results. Diversity and inclusion can impact positively on aspects such as innovation efficiency and teamwork on different phases of software development.

Therefore, a broad and challenging question arises related to “*How to adapt SE practices to include people with disabilities in the software development?*” Certainly, getting the answers requires a lot of research effort for many years, considering several disabilities, stakeholders, and activities. In this study, the scope was reduced and the focus was to investigate how to elaborate questionnaires that can be useful for deaf people. Questionnaires can be used differently in SE, for example, in requirements elicitation, when face-to-face communication between the software engineers and the final users is

not possible [Dardenne et al. 1991, Moore and Shipman 2000]. Additionally, they can be useful to promote data collection in many situations: during assessment of the SE capability in companies [Zubrow et al. 1994]; during software evaluation, including the graphical user interface evaluation [Dix et al. 2003, Bustillos et al. 2019]; in SE surveys, case studies, or experiments [Wohlin et al. 2012]; and to gather information about users, tasks, and workflows in User Centered Design aiming at involving the end user [Wilson 2013]. In special, questionnaires can be very important to promote communication between stakeholders.

More specifically, the purpose of this paper is to present guidelines for the elaboration of questionnaires useful for deaf people, contributing to their participation in the SE process. A qualitative research involving a case study with the participation of deaf people and an interpreter was considered in this research. Rather than searching for numerical measurements, the qualitative studies attempt to analyse texts, observations, video, and artifacts to understand complex situations. Analysis of these data often raises challenges that rarely bring up with quantitative data, as we struggle to interpret ambiguous comments and understand complex situations. The goal of qualitative analysis is to turn the unstructured data found in texts and other artifacts into a detailed description about the important aspects of the situation or problem under consideration [Lazar et al. 2017].

Using the thematic analysis method [Braun and Clarke 2006], guidelines leading to an questionnaire considering accessibility issues were identified. It is hoped that professionals can apply such guidelines in the elaboration of new inclusive questionnaires. This paper is organized as follows. Section 2 presents related work. The methodology used in this study is described in Section 3. Section 4 provides a description of resultant guidelines, Section 5 discuss the main threats to validity, and Section 6 concludes the paper.

2. Related Work

Ferreira and Bonacin [Ferreira and Bonacin 2014] analyzed the semantic and normative aspects of Web content production and consumption by means of participatory studies with deaf users. These studies resulted in the elicitation of 121 key problems, and the respective high level design recommendations. These are design solutions that must be implemented by the developers of detailed design solutions. For example, one design solution is to include options that explain the various meanings of a word, exemplifying them with contextualized scenarios where it could be used. Certainly, these recommendations are useful for online questionnaires design.

In relation to the questionnaire technique, Berke et al. [Berke et al. 2019] investigated how to translate standardized usability questionnaires into American Sign Language. The authors stated that to ensure that technology is accessible to diverse users, researchers and designers should ideally include people with disabilities during the studies. The main focus is on finding alternatives to make it easier for researchers to include people who are deaf or hard-of-hearing in such studies.

Schrepp et al. [Schrepp et al. 2017] discussed that a user experience questionnaire is an efficient method to access the impressions of a larger number of users toward a product. However, such questionnaires must be adapted to the language and to the level of language understanding of the intended target groups. They presented an example of

the creation of a Portuguese language version and a special version for children. The process to create the Portuguese language version included the translation process, the scale consistency, and the comparison with Spanish results. The process to create a version for children included the analysis of the existing user experience questionnaire, creation of alternative items, evaluation, and usage of simple language.

Silva et al. [Silva et al. 2020] state that SE must consider the particularities inherent in physical disabilities, such as deafness. The authors presented lessons learned about requirements engineering that uses oral-auditory and visual-spacial communication to address hearing and deaf stakeholders. In our study, we are considering the textual content as communication resource.

3. Methodology

3.1. Design and preparation for data collection phases

First of all, we carefully studied the main concepts about software accessibility and deafness and carried out a systematic literature review regarding how to develop accessible web interfaces for deaf people [omitted]. We could identify many important accessibility requirements, such as: to offer semantics, cohesion, and simple language of textual and not textual information; to provide precision in the reproduction of texts and sign language; to provide video in sign language; to provide sufficient time for understanding; to provide dictionary for sign language and text; to allow notifications in vibrating or visual mode; to replace audio with images, text or sign language; to present captions in lives or recorded videos; to present captions of ambient noise; and to provide sign language recognition and translation.

Considering that the results of the systematic literature review were still very generic and could be refined and detailed, we proposed a case study involving deaf users and an interpreter. We defined the main activities to achieve our goal considering the case study approach [Wohlin et al. 2012]. In the *design phase*, we defined the objective (obtain guidelines to elaborate helpful questionnaires which can be used by deaf people), the case (questionnaires for deaf people), the theory (SE and accessibility theories), the research questions (how to elaborate accessible questionnaires for deaf people?), the methods (interviews) and the selection strategy (interpreter and deaf people as participants).

In the *preparation for data collection phase*, we defined the process for gathering the data, as presented in Figure 1. In general, it consisted of producing an initial version of the questionnaire, conducting evaluations with the participation of an interpreter, refactoring the questionnaire, conducting evaluations with users, analyzing the data using the thematic analysis method, and obtaining the guidelines and the third version of the questionnaire considering accessibility issues.

3.2. Collection and analysis of data phases

In the *collection of data phase*, the process was carried out. Considering the results of the systematic literature review, we defined the first version of the questionnaire (using Google Forms tool) that we judged could be understood by deaf people. Two evaluation cycles were applied to the questionnaire in order to identify barriers and guidelines for the construction of an inclusive and useful questionnaire. It was composed of 20 questions and the subject was the experience of deaf people with the use of the internet.

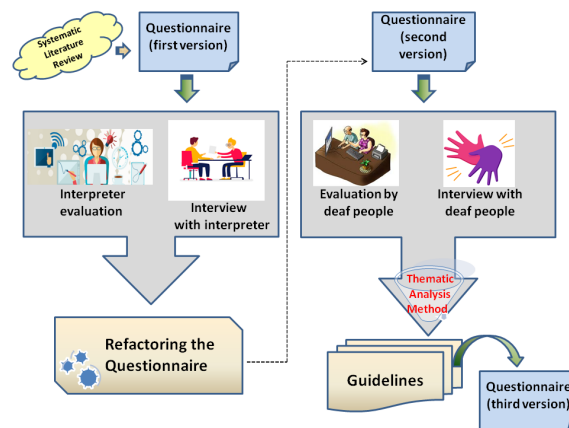


Figure 1. Main activities of the process

To design our questionnaire, we selected closed and open questions. We used closed questions to raise the participants' background (i.e., gender, educational level, skill level in the Portuguese language and Libras (Brazilian sign language), level and origin of deafness, etc) and general information on the use of web pages by participants (i.e., assistive technology resources used, access frequency to web pages - including governmental ones, need an interpreter to access web pages, level of experience in using web pages, elements of the web pages that help in their navigability, etc). In particular, we selected single and multiple responses for the closed questions, depending on the focus of each question. On the other hand, we chose open questions to collect specific and personal information on the use of web pages (i.e., difficulties and barriers found to access web pages, the reasons for accessing the web pages, citations of known accessible and no accessible web pages, etc). Considering the expertise of the interpreter, fluent in Libras, the first evaluation of the questionnaire was carried out. She could evaluate the questionnaire in detail and, afterwards, an unstructured interview was started.

The main suggestions indicated by the interpreter to improve the questionnaire were: i) use of visual separators between questions, helping to prevent users from having difficulties in knowing where each question starts and ends; ii) replace some words with simpler words, for example, "Mild and bilateral disability" by "Mild (inability to hear sounds below 30 decibels) in both ears"; iii) insert a brief description at the beginning of the questionnaire presenting its purpose; iv) avoid words in the plural form; v) use of verbs in the infinitive form; and vi) create independent questions.

The questionnaire was refactored and the second version was obtained. The 20 questions were maintained and changes were made: i) inclusion of a header indicating the objective of the questionnaire and the authors of the study; (ii) visual separation between questions using a horizontal line at the end of each question; (iii) word changes from the plural to the singular and verbs to the infinitive form; (iv) use of synonyms in order to simplify writing and understanding; and (v) exclusion of dependency between questions.

The interpreter contacted 14 deaf people and four of them accepted to participate in this study. All participants have high levels of deafness and varying skill levels in the Portuguese language. Three of them are fluent in Libras. With respect to their educational levels, 2 participants held high school degrees, 1 participant held higher education and 1

participant held the elementary school. Their ages ranged from 29 to 37 years old. Three participants mentioned that they use the internet frequently (every day) and one of them uses the internet eventually.

The main task performed by the participants was to answer the refactored questionnaire so that the barriers and difficulties encountered (if any) could be identified. Each participant used an average of 30 minutes to answer the 20 questions. Afterwards, during the interviews, the interpreter translated from Portuguese to Libras (and vice versa) to promote the communication among researchers and deaf people. Certainly, the assessment carried out was an opportunity to validate the results obtained in the first assessment cycle and the changes made to the questionnaire.

As mentioned, to better understand the data obtained with the two evaluation cycles (and consequently obtain the third version of the questionnaire), we used the thematic analysis method. Therefore, in the *analysis of collected data phase*, all the data, information, and users' experiences with the questionnaire could be carefully analyzed. In general, patterns could be observed, for example, the difficulty in understanding the questions by deaf people is evidenced when a term or word within the statement is unknown. In addition, the use of a single word without alternative synonyms can lead the user to a wrong answer or even incapacitate him/her to complete the questionnaire.

The thematic analysis method was used in this phase considering concepts from literature [Braun and Clarke 2006, Fereday and Muir-Cochrane 2006, Nowell et al. 2017]. The first phase was familiarising with the collected data. This included transcribing data and reading all the corpus. Other important activity of thematic analysis is *generating initial codes*. Codes identify a feature of the data that appears interesting to the analyst, and refer to "the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon" [Boyatzis 1998]. Interviews with the users provided us with rich material to generate initial codes. Also, the interpreter's participation was crucial because she provided additional information that they could not inform us. Therefore, her expertise was essential at this stage to contribute to the understanding of the main problems identified by users. Table 1 presents the initial codes.

In general, we observed that it is important to present information in a very objective way, avoiding misinterpretation. The use of each word must be carefully thought out. For example, technical terms (such as "websites", "blogs") should be avoided. Initially, we constructed the sentences in a wrong way, which generated a lot of confusion among the participants. The grammatical structure (object - subject - verb structure) needs to be considered according to the characteristics of the target audience. The use of simple and practical examples contributes significantly to understanding. The presentation of the questionnaires and the items (or elements) used to build them must also be considered. Small and closed-end questionnaires should be used whenever possible. It is important to mention that open-ended questions are not problems if software engineers are able to ensure that the questionnaire responses can be understood by them in such a way that the communication be effective, since the wording by deaf people has peculiarities.

The next phases of the thematic analysis method are the identification, review, and definition of themes. This phase begins when data have been initially coded and collated.

Coded for	Data extract
Unknown writing	<ul style="list-style-type: none"> - There are unknown words and signs: I don't know what is "synonym" - I think that "Creator" is God and I can not understand "Creator of sites" - I can not understand "e-mail address", "literacy", "website", "blog", "enough time" - There was confusion between email address and physical address, place of residence (extract by interpreter)
Unusual task	<ul style="list-style-type: none"> - I don't know how to classify with numbers - I can not do this (when the answer of a question defines the next question to be answered, i.e., there is non-linear navigation among questions)
Importance of examples	<ul style="list-style-type: none"> - I would like to have "easy words" (meaning examples) - I need some examples about this - The use of common everyday examples facilitate the understanding of all users. For example: the words "facebook" and "internet" were used to explain the word "website" (extract by interpreter)
Difficult interpretation	<ul style="list-style-type: none"> - Use the object - subject - verb structure to build sentences (extract by interpreter) - I can not understand it - I need the help of an interpreter just to answer questionnaire - Different levels of literacy influence the understanding of the questionnaires and the answers. For example, some of them may not understand verb conjugation, plural, etc. (extract by interpreter) - There are signs used to translate different words with a similar meaning. For example: the sign for house is the same to cabin, home, tent, etc. Therefore, words need to be carefully selected to avoid misinterpretation (extract by interpreter) - Open-ended questions require additional attention (extract by interpreter)
Presentation	<ul style="list-style-type: none"> - It is important to have a visual separation between the questions (extract by interpreter) - Present a brief description containing the objective of the research, audience, and authors at the beginning of the questionnaire (extract by interpreter) - Whenever possible, prefer concise questionnaires (extract by interpreter) - People talking slowly in videos contribute to lip reading (extract by interpreter)
Essential elements	<ul style="list-style-type: none"> - Videos translating content into sign language are useful - No time restriction to answer the questions - Texts explaining graphics are fundamental - Present synonyms and word meanings (extract by interpreter) - Present synonyms and sign meanings – consider slang, jargon, and regional terms (extract by interpreter)

Table 1. Initial codes

It focuses on the analysis at the broader level of themes, rather than codes, involves sorting the different codes into potential themes, and collating all the relevant data extracts within the identified themes. Usage of visual representation (tables, mind-maps, etc) is suggested. Figure 2 presents the thematic map for this case study, representing the themes in ellipses and the sub-themes in rectangles. We identified three main themes, related to tasks, presentation, and writing.

The use of thematic analysis method helped us to identify the key points that should be modified in the questionnaire, version 2. It was refactored and the third version

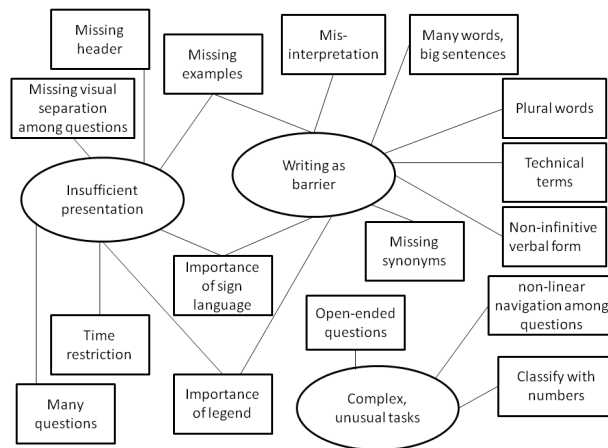


Figure 2. Thematic Map

was obtained. The 20 questions were maintained and the following changes were made: i) use of the object - subject - verb structure to build sentences; ii) inclusion of examples and synonyms whenever possible; iii) restricted use of technical terms (only the most common ones were kept, for example, web, internet); iv) usage of objective sentences; and v) restricted use of open-ended questions. The last phase recommended [Wohlin et al. 2012], *reporting results*, is presented in the format of guidelines in the Section 4.

4. Guidelines to define questionnaires for the deaf people

To facilitate the usage of the guidelines, we organize them into three parts: definition of structure, definition of content, and presentation of content, as described below.

Guidelines to define the questionnaire structure

- Create a header including the objectives, the audience, the authors of the questionnaire, and their affiliation;
- Create visual separators before and after each question to relate each one with its possible answers; and
- Avoid questionnaires with too many questions.

Guidelines to define the questionnaire content

- Create simple, direct and brief textual content;
- Use Likert scales as answer choices instead of numerical scales;
- Avoid open-ended questions;
- No use nouns in the plural form;
- Utilize verbs only in the infinitive form;
- Change the structure of the sentences following the order: object, subject, and verb; and
- Avoid dependence among questions.

Guidelines to present the questionnaire content

- Provide videos translating content into sign language or interpreter assistance by video;
- Provide meanings, synonyms, and examples for both questions and answer choices; and

- Apply the questionnaire with no time restriction to users answer the questions.

In more detail, the questionnaire should initially include a header with a title, a description of its objectives, the name of authors, and their affiliation. Also, each question of the questionnaire should be visually delimited so that users understand its beginning and end.

The text of each question should be clear, short, direct, concise, and no contain slang, jargon, regional terms or ambiguous terms. For instance, avoid “e-mail address” and replace it with “e-mail”, as an address for the hearing impaired means place of their home. In case of multiple-choice questions avoid using a numerical scale with subjective meaning for the choices (e.g., rate your math knowledge level from 0 to 10) and replace them for concrete and objective ones using a Likert scale (e.g., very, more or less, little).

Besides, each question may be associated with help, containing synonyms of the terms used in the text and examples of valid options to fill the answer. The verbs used in the text of the questions must be in the infinitive form and the nouns in the singular form, mainly because users with prelingual deafness (refers to deafness that occurs before learning speech or language) may not know how to differentiate plural of singular and how to distinguish verbal conjugations. Also, Libras’ grammar follows a different order in the composition of sentences, that is, object, subject, and verb; therefore, questions should be written in that order to facilitate the understanding by users with prelingual deafness.

5. Threats to Validity

Construct validity: the questionnaire is a threat. The style and presentation of the questions and the possible answers may have influenced the results. However, we try to provide different formats to encompass different possibilities, for example, questions to choose an option, questions to choose many options, etc. The questionnaire was used because it is the focus of our investigations and to support the interviews. In fact, it was useful in helping to identify several key points for improvement. The first version of the questionnaire came from our previous knowledge and experience, which is another threat. The method used to the qualitative analysis is another threat because different results could be reached if alternatives methods were used.

Internal validity: threats to the internal validity are different literacy levels of subjects and different levels of experience with web. To mitigate the first threat, the presence of an interpreter could help users to understand the questionnaire and, to mitigate the second threat, the presence of researchers responsible for this research could help users to understand technology details.

External validity: the number of subjects (four deaf users and one interpreter) represents threats to external validity. We believe this is the most difficult threat to mitigate. Indeed, as presented by Lazer et al. [Lazar et al. 2017], typically, researchers have utilized smaller size datasets, due to the need for researchers to recruit their own participants and collect their own datasets. Additionally, authors state that for much of the research, not just any human being is appropriate for taking part as a participant, i.e., participants need to be representative in terms of the domain. In our study, certainly we had a challenge in relation to recruitment. Another threat is the introduction of bias during data analysis. To mitigate this, the authors extensively discussed the data and the results Whenever necessary the support of the interpreter was requested.

Conclusion validity: considering the relation between treatment and outcome, we tried to mitigate it by combining data from different resources, such as data obtained with the interpreter evaluation of the questionnaire, qualitative data obtained with evaluation of questionnaires by deaf users, and interviews. We believe data collection and analysis were properly considered in this study.

6. Conclusion

We consider that this article presented a good initial proposal, based on scientific methodology (systematic literature review, case study, qualitative research). Certainly, we would like to have reached a larger number of people and generate statistical data. We are aware that this would improve our study and we are considering different approaches to continue this research. As the next more immediate future work, we suggest: (i) to evaluate the last version of our questionnaire with a huge mass of deaf people aiming to identify other guidelines using the same or similar research method adopted in this work; (ii) to apply the research method adopted in this paper to adapt existing techniques used in diverse phases of the software system life cycle to engage people with disabilities to promote equality for all; and (iii) to deepen the existing studies to advance the disability-aware SE, regarding the various stakeholders who can participate throughout the software system life cycle.

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