

# Accessible Software Design: thinking outside the box

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**Abstract.** Accessibility is generally approached as an implementation aspect, and people with disabilities are not involved in the early design stages. On the other hand, the rise of Design Thinking has led to a rethink of whether traditional empathy methods (interviews and surveys) capture the real needs of people, particularly those with disabilities. This paper presents an extension of the article published in the *XXIX Argentine Congress of Computer Science (CACIC 2023)*, where an empathising guideline with people with disabilities using Design Thinking experiences was proposed to design accessible software from scratch. In addition, in the article published in CACIC 2023, this empathising guideline is used to design and explore two experiences with two people, one with motor difficulties (in this case affecting speech and writing) and another with Down syndrome. Furthermore, this article published in CACIC 2023 proposes reflecting on the best resources for empathising. The present work extends the article published in CACIC 2023, expanding with more detail the conceptual framework that frames the empathising guideline and enriching the descriptions of the two experiences. In addition, this present work adds recommendations regarding possible resources to be used in each guideline's item. We hope that this work will contribute to accessible software design.

**Keywords:** Accessibility, Design Thinking, Software, Disability, Human-Centered Design.

## 1 Introduction

Accessibility is usually addressed at later stages of development as it is considered an implementation issue [1], which generates additional work overload to make the accessible software. The resulting product is often unusable or frustrates users with disabilities [2], as the software was not designed with their needs in mind [3]. For this reason, it is critical to actively involve people with disabilities in software design [4].

Design Thinking (DT) [5] is a Human-Centered Design approach that uses designers' methods to create innovative solutions according to people's needs. The first stage of

DT is to focus on empathising to identify or discover what people need. Moreover, empathy could contribute to a more accessible world [6]. However, DT has little explored in the design of accessible software [7]. This motivates our research.

Empathise can be achieved using direct or indirect interactions [8]. Direct interventions involve collecting ‘*first-hand*’ information, for example, questionnaires and interviews with representative users [9]. At the same time, indirect interactions may involve, for example, on-site observations of representative users or interviews with third parties [10]. It should be noted that indirect interactions may be biased and not reflect the actual experiences of those who want to empathise [8].

Different resources can be used for the empathise stage of DT, which can involve direct or indirect interactions. However, it is advisable to approach this stage with direct interactions, and indirect interactions should be used as complementary [7]. On the other hand, traditional DT resources used in direct interactions, such as interviews or questionnaires, may not generate genuine empathy with people who wish to empathise with [11] because their real needs are not sometimes identified. This is part of the motivation for this paper.

In [7], we have presented a conceptual framework of DT for designing accessible software from scratch. Furthermore, in [7], we explored empathising with people with colour-blind disabilities to begin understanding their real software needs.

This paper presents an extension of the article published in [12] at the ‘*XXIX Congreso Argentino de Ciencias de la Computación (CACIC 2023)*’, where an empathising guideline with people with disabilities using Design Thinking experiences was proposed for the design of accessible software from scratch. This guideline focuses on direct interactions and is framed in the conceptual framework proposed in [7]. Furthermore, in [12], this empathising guideline was used to design and explore two experiences with two people: a person with motor difficulties, in this case affecting speech and writing, and a person with Down syndrome.

This paper extends the article published in [12], providing more detail on the conceptual framework that frames the empathising guideline, just like enriching the descriptions of the two experiences presented in [12]. In addition, this paper incorporates recommendations for possible resources to be used in each item of the guideline.

Like in [12], we hope this paper will provide a space for discussion that contributes to making the problem visible, looking to reflect on how to detect the real needs of people with disabilities to be able to design adaptations in software from the early stages and make it accessible from scratch.

The paper is structured as follows. Section 2 describes some related work. Section 3 provides more details on the conceptual framework that frames the empathising guideline (presented in [12]) and details the guideline (as was given in [12]). Section 4 enriches the descriptions of the two experiences presented in [12]. Section 5 incorporates recommendations for possible resources that could be used in each guideline’s item. Section 6 generates a space for discussion. Conclusions and future work are mentioned in Section 7.

## 2 Related Work

In recent years, DT has started to be used to design software solutions. For the aim of this paper, it is interesting to know how different authors address this topic, particularly the empathise stage of DT with people with disabilities. Two papers are described below.

In [10], DT is used to design and develop a tangible user interface for the literacy process of students with Down syndrome. For the empathise stage of DT, they interviewed fifteen Special Education teachers, which allowed them to identify two literacy methods used with these students. Then, each method was explored in depth by interviewing its creators, and a literature review was carried out to complement the information. Finally, the authors conducted an on-site observation of the teachers working with the students to understand the methods' application. In other words, all resources used involve indirect interactions to empathise.

On the other hand, in [9], a DT experience with a transportation company is presented to improve the service for people with mobility challenges. For the empathise stage, the activities described below were carried out. The author investigated what happens to transport users (using *Netnography*<sup>1</sup>), how companies perform (using *Benchmarking*<sup>2</sup>), and how a transport user's experience is improved (using the *Safari*<sup>3</sup> resource). Questionnaires and interviews with transport users were carried out. The information was organised using different resources<sup>4</sup> (*User Persona*, *User Journey* and *Empathy Map*). In summary, [9] only questionnaires and interviews involve direct interactions; however, these resources might not have achieved genuine empathy [11].

The following describes two papers that explore how people with disabilities (Down syndrome and motor difficulties) use gestures in mobile applications. These papers do not use DT but are interesting in terms of the exploration done about the software.

In [13], the authors present a case study conducted with fifteen young people with Down syndrome regarding the use of the most basic gestures in mobile applications. The study divides young people into three groups, all with no or little use of mobile devices. The first group was given six apps for training for six different gestures. The second group received only an explanation of the gestures. At the same time, the third group had no information at all regarding the gestures. Then, all three groups used the Google Earth application (selected for having an unintuitive interface regarding the use

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<sup>1</sup> *Netnography* was used to investigate social networks, web pages, forums, and written interactions of people who use (or have used) public transportation and have expressed their feelings, emotions, and experiences.

<sup>2</sup> *Benchmarking* was carried out through an exercise called 'Look for the 7 differences', during which they investigated buses in other communities and countries.

<sup>3</sup> The *Safari* resource consists of an in-situ simulation that allows to live the experiences of the people with whom we are trying to empathise.

<sup>4</sup> The '*User Persona*' resource was specified with the data collected to represent a fictitious person who uses the bus and has mobility difficulties. Then, with the '*User Journey*' resource, strengths/weaknesses were determined for the profile defined in '*User Persona*'. Finally, based on all the information collected, the '*Empathy Map*' was used to reflect the emotional aspects of the bus users' feelings and thoughts.

of gestures). In [13], the authors mentioned that training applications have been facilitated using Google Earth. The authors identify that the gestures of *rotating*, *holding down*, and *dragging* (or *moving*) are the most difficult for these young people to perform, although they do not describe how they reached this conclusion.

On the other hand, in [14], the difficulties generated by gestures in mobile applications are studied with ten people with different challenges of reduced mobility in the upper limbs. For this, the authors surveyed the most used gestures in existing applications. Based on this, they developed a prototype program for the iPhone to determine which gestures people with different mobility challenges cannot make. After using the prototype, people with reduced mobility completed a questionnaire with a series of questions about the usability of the prototype. In [14], the author identified for the ten people who used the prototype, based on the questionnaire responses, that the most challenging gestures to perform were *rotate* and *zoom*.

In both [13] and [14], it is appreciated that the explorations focus purely on the gestures' usability and do not empathise with people.

### 3 Empathise with people with disabilities

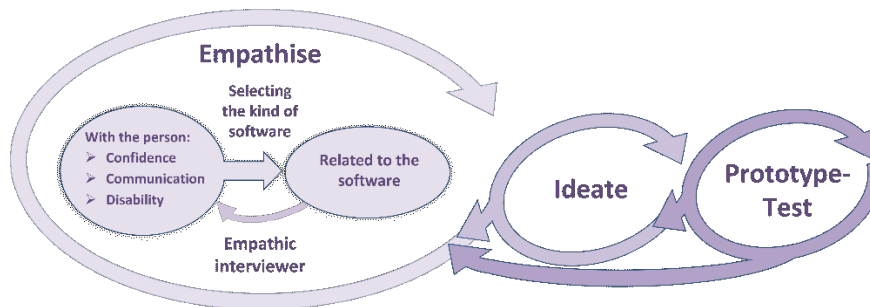
As mentioned above, in [7], we presented an initial proposal for a conceptual framework of DT for designing accessible software from scratch. This framework proposes three stages for approaching DT: empathise, ideate, and prototype/test. It is essential to mention that, in [7], we do not provide details on these stages.

In [12], we presented an empathising guideline with people with disabilities focusing on direct interactions. This guideline was proposed for the empathise stage of the conceptual framework DT presented in [7].

This paper contributes by providing more details below for the conceptual framework that frames the empathising guideline (presented in [12]). In addition, this section details the guideline's items as they were given in [12].

#### 3.1 Extension of the conceptual framework of DT for designing accessible software from scratch

Based on the conceptual framework of DT proposed in [7] for designing accessible software from scratch, which defines three stages: empathise, ideate and prototype/test, as mentioned before; in this paper, the empathise stage is extended with the concepts addressed in the guideline proposed in [12]. This extension can be seen in Figure 1. The interviewer should initially empathise with people, generating confidence, knowing how they communicate and learning about their disability; then, taking this as a starting point, move on to an instance of empathise related to the software. In addition, the interviewer needs to have empathy and always maintain active listening; that is why, in Figure 1, this role is related to the whole empathise stage. It is essential to mention that selecting the kind of software to explore can be established beforehand before empathising with people with disabilities or based on what has been collected. In other words, this is a flexible aspect, so it is outside of the flow, as shown in Figure 1.



**Fig. 1.** Conceptual framework of DT for designing accessible software from scratch. Extension with more level of detail in the empathise stage.

### 3.2 Empathising guideline with people with disability

The guideline's items (for empathising with people with disabilities, focusing on direct interactions) are detailed below, as they were given in [12].

- *Choose an empathic person to conduct the empathise stage.* It is essential to consider the person's level of empathy to achieve more pleasant communication and encourage active listening to the needs of people with disabilities. There are several tests to measure empathy [7].
- *Generate a bond of confidence with the person who wish to empathise with.* The existence or absence of a previous link determines how to proceed. If you do not know the person, you should have to generate this bond of confidence to be able to carry out any empathise activity about the software. For this, it is recommended to use, for example, the resource called '*Interview to Empathise*' [15]. Whether a previous bond exists or has been generated, the people who want to empathise should be told what the experience to be carried out consists of and why their contribution is extremely useful, together with an '*Informed Consent*' document (which provides all the details of the experience).
- *Determine the predominant communication of the person who wish to empathise with.* Knowing how people communicate becomes critical to better reach and understand their needs. People can be visual, auditory, kinesthetic (they learn by what they do and touch), or a combination of these [16]; this impacts how they express themselves and incorporate information. Preponderant communication can be determined, for example, through the resource of '*Direct Observation*', and based on the result, the selection of resources can be dynamically adapted to empathise with each person in the most appropriate way.
- *Learn about the disability of the person who wish to empathise with.* It is essential to know how the person's disability impacts their daily actions. Depending on how close the interviewer is to the person's disability, the level of depth with which they

should explore the disability. In this sense, it is possible to learn about the disability through questions asked to third parties (experts, family members),

- *Define what to find out about the kind of software to be designed.* Each kind of software may have different characteristics and dynamics; defining which one wants to design is essential to guide how to carry out the software empathise stage and what resources to use.
- *Determine what resources to use to empathise related to the software that want to design.* Generating resources that allow empathising with the software, for example, a mock-up of some relevant aspect of the software; this resource style is easy to design/assemble and does not take much time. Another option is to use a *'Prototype to Empathise'*<sup>5</sup> [15].

## 4 Empathy Experiences

This section enriches the descriptions of the two experiences presented in [12]. For these two experiences<sup>6</sup>, the guideline proposed in Section 3.2 was implemented with two people with disabilities. One of them has motor difficulties that affect the clarity of speaking and writing, referred to as T. The second person has Down syndrome, referred to as J. Both people regularly use mobile devices, have acquired literacy, participate in theatre and dance groups, respectively, and in the case of J, also have a job.

Below, each guideline's item will be addressed for both experiences, which took place in parallel and personalised for each person.

To *'Choose an empathic to conduct the empathise stage'*, it was necessary to consider the most empathic person in the work team to conduct the experience; for this purpose, the IRI test<sup>7</sup> [17] was used. Two of the team members gave, as a result in the empathic concern dimension, a value above the average, of which the one who had the closest link with people who wish to empathise with was chosen. From now on, this person will be referred to as the interviewer. Table 1 describes how three of the guideline's items (*bond of confidence*, *communication*, and *disability*) were approached.

In terms of *'Defining what to investigate concerning the kind of software to be designed'*, we decided to investigate the use of gestures in mobile applications for both T and J, motivated by the frequent use of mobile devices and the scarce direct empathy found in the literature. We decided to explore the gestures move (or drag, which involves holding down), zoom, and rotate, considering that they can generate challenges, as mentioned in Section 2, for the two disabilities explored in this paper.

For the guideline's item *'Determine what resources to use to empathise related to the software that want to design'*, the resources listed in Table 2 were chosen.

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<sup>5</sup> The *'Prototype to Empathise'* has functionality (i.e., it can be interacted with). It can be either software created for that purpose or an existing one. The concept of *'Prototype to Empathise'* differs from the concept of *'Software Prototype'* since it is made or used only for empathising and will not become the final software.

<sup>6</sup> To preserve the identity of the people involved, they will be identified with a letter.

<sup>7</sup> The IRI (Interpersonal Reactivity Index) test allows for measuring empathy in adults.

**Table 1.** Performance of three items of the empathising guideline.

Guideline's item	T (Motor difficulties)	J (Down syndrome)
<i>Generate a bond of confidence with the person who wish to empathise with</i>	The interviewer knew the person previously. However, they had not been in contact for some time, so the link had to be reestablished.	The interviewer did not know J. It was decided to conduct a face-to-face 'Interview to Empathise' [15] with the assistance of a third person who was the link between the interviewer and J; this person (henceforth R) fulfils a role similar to a tutor for J.
<i>Determine the predominant communication of the person who wish to empathise with</i>	The interviewer refined it during the re-engagement with T, which occurred first by contacting T via WhatsApp application and then through a Google Meet video call (set up with the option of subtitles due to T's speech difficulty).	The interviewer refined it through 'Direct Observation' during the 'Interview to Empathise'.
<i>Learn about the disability of the person who wish to empathise with</i>	The interviewer knew T, so the interviewer knew how disability impacted T.	The interviewer learned about Down syndrome through consultations with third parties: with an expert (hereafter E) to learn about the generalities and with R to learn about J.

**Table 2.** Resources used to empathise related to the software that want to design.

Resource Used	Description	T (Motor difficulties)	J (Down syndrome)
<i>Prototype to Empathise</i>	Using a known application.	<i>Word Wonders</i> <sup>8</sup> .	<i>Candy Crush</i> <sup>9</sup> .
<i>Inquiry Questions</i>	Answering questions.	Contextualized to the use of <i>Word Wonders</i> .	Contextualized to the use of <i>Candy Crush</i> .
<i>Prototype to Empathise</i>	Editing a WhatsApp image.	Contextualized to theatre (a topic of interest of T).	Contextualized to horses (a topic of interest of J).
<i>Inquiry Questions</i>	Answering questions.	Contextualized to the complexity of gestures' use.	Contextualized to the complexity of gestures' use.

In Table 2, the first 'Prototypes to Empathise' were the *Word Wonders* and *Candy Crush* applications. These were chosen for T and J, respectively; this decision was made

<sup>8</sup> Word Wonders homepage: <https://play.google.com/store/apps/details?id=com.fugo.wow>, last accessed 2023/05/12.

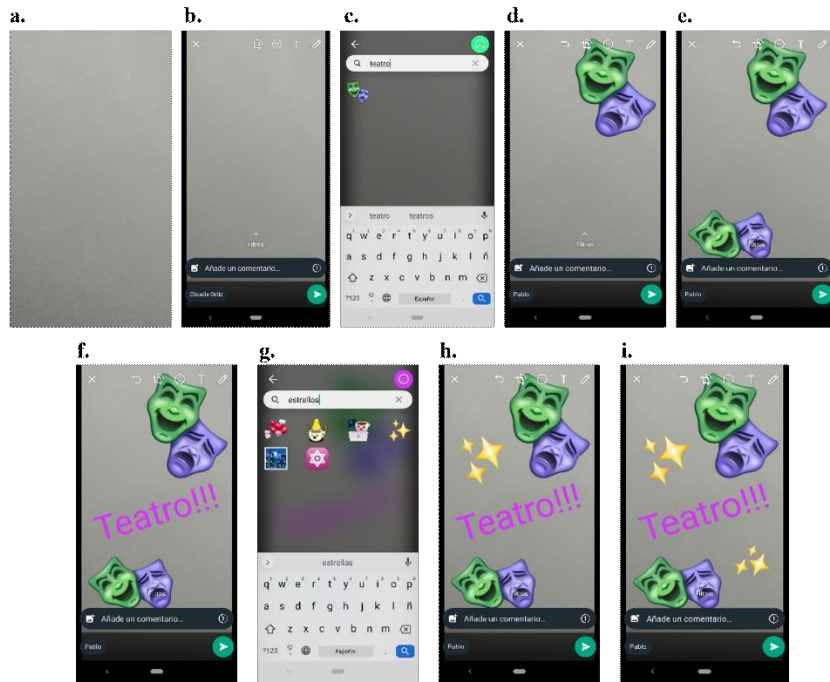
<sup>9</sup> Candy Crush homepage: <https://play.google.com/store/apps/details?id=com.king.candycrush-saga>, last accessed 2023/05/12.

considering the information obtained in the previous interactions with each of them. Table 3 lists the *'Inquiry Questions'* related to the complexity of using each application.

**Table 3.** Inquiry Questions to formulate at the end of using the known applications.

Question	T (Motor difficulties)	J (Down Syndrome)
1	What is the most complex thing about using <i>Word Wonders</i> ?	What is the most complex thing about using <i>Candy Crush</i> ?

For the *'Editing a WhatsApp image'* (from Table 2), sequences of images presented to both T and J were previously designed to test the use of gestures in a guide way, for example, adding emojis and texts and placing them in certain places with a particular inclination and size. *WhatsApp* was selected because it is an application that uses T and J frequently. In addition, these images were contextualised according to each one's interests (which were identified by the interviewer in previous interactions). Figure 2 shows the sequence to explore the use of gestures with T.



**Fig. 2.** The sequence of steps designed to explore with T the gestures' use.

As in Figure 2, the exact sequence was designed for J, but some images and texts were related to J's interest in horses. Figure 3 shows some images designed for J.

Table 4 lists the *'Inquiry Questions'* defined to learn about the complexity of *'Editing a WhatsApp image'*. These questions were the same for both T and J.

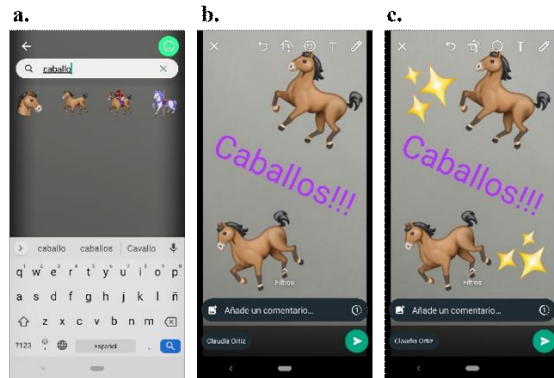


Fig. 3. Some images of the sequence of steps designed to explore with J the gestures' use.

Table 4. Inquiry questions to formulate at the end of image editing.

Questions	T (Motor difficulties) and J (Down Syndrome)
2	How complex was it to <i>move</i> the emojis to each place?
3	How complex was it to <i>zoom</i> the size of the emojis?
4	How complex was it to <i>rotate</i> the emojis?

In two face-to-face meetings, one with each person, it was first proposed that they use the known application freely. Figure 4.a can be appreciated as T interacting with *Word Wonders*, whereas Figure 4. b is J using *Candy Crush*. This allowed the interviewer to conduct a 'Direct Observation' of their habitually using mobile devices.

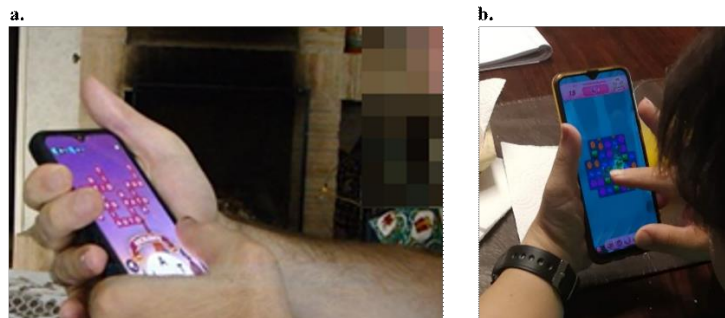


Fig. 4. Using the known applications.

After a few minutes, the interviewer asked each of them the questions in Table 3. T, unlike J, answered by WhatsApp, although T and the interviewer were in the same physical place; this was decided to overcome the challenges in oral communication that have T.

The interviewer observed that none of them had problems; they used them fluently. However, T mentioned, '*Sometimes when I raise my finger; it was difficult for me*'; on

the other hand, T focused on the fact that the most challenging thing was sometimes guessing the word (used *Word Wonders*). In the case of J, the response was: *'It's easy. I've been playing for more than a year'*.

Subsequently, the interviewer proposed editing a blank image using WhatsApp. As mentioned above, this editing activity was the same for both people; the only thing that varied was the theme used for each one since it was contextualised according to their interests, as shown in Figures 2 and 3.

For editing, they were told what to do step by step and shown an image of how it should look, with little indication of how to do it. Figure 5 shows two of the steps performed by T, with the interviewer's cell phone on the left and the T on the right.

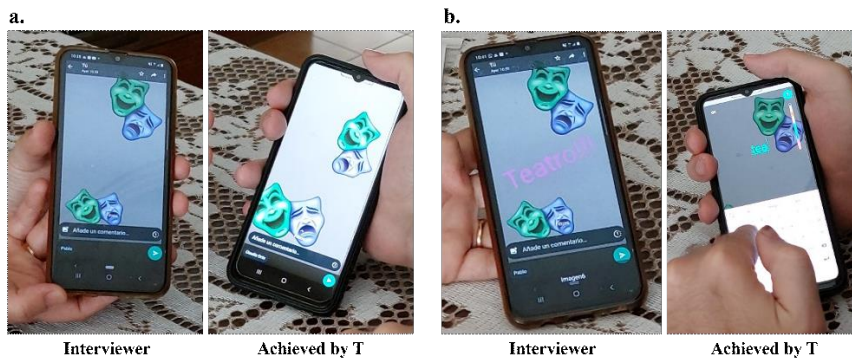


Fig. 5. Some steps achieved by T.

Figure 6 shows a general picture of the empathy experience with T. In addition, the final screens can be observed in the figure, both from the interviewer and the final result achieved by T, after following the steps of the editing sequence in Figure 2. Note that T's achievement was similar to what the interviewer proposed in terms of the distribution and size of the emojis and text.



Fig. 6. Experience to empathise with T about gestures.

After editing, T was asked about the complexity (of move, zoom and rotate) using the three questions in Table 4. T answered via WhatsApp, and to all questions, T answered, *'I had no problem'*, which was in line with what the interviewer observed.

On the other hand, Figure 7 shows two steps in J's sequence, with the interviewer's mobile phone on the left and J's mobile phone on the right.

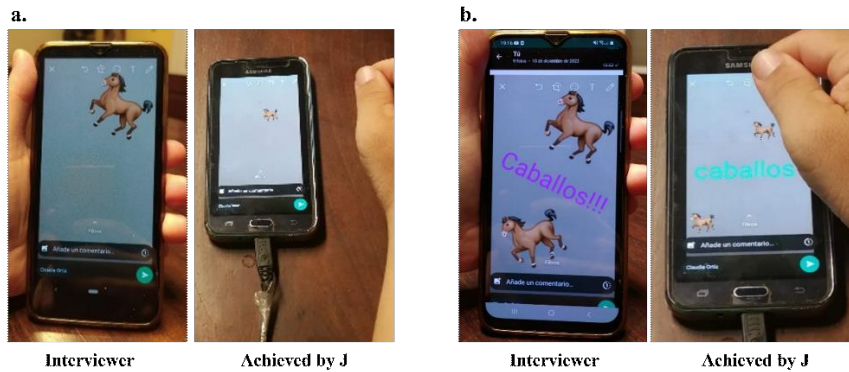


Fig. 7. Some steps achieved by J.

Figure 8 shows a general picture of the empathy experience with J. It is essential to mention that J was constantly dispersed during the experience. In addition, the final screens can be observed in Figure 8, both from the interviewer and the final result achieved by J. A significant difference can be observed in terms of the size and inclination of the emojis and the text.

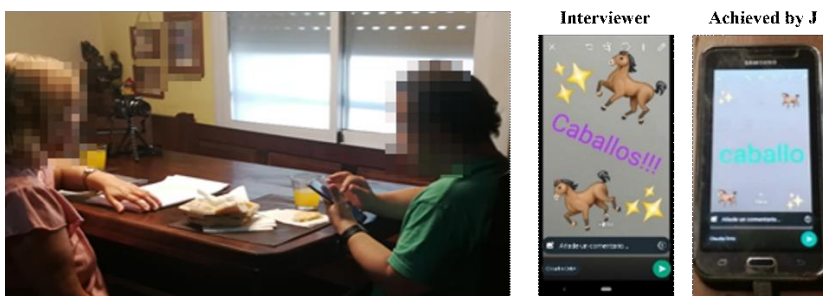


Fig. 8. Experience to empathise with J about gestures.

After the editing was finished, J was asked about the complexity of each gesture (move, zoom and rotate) using the three questions in Table 4. When the interviewer asked the first question, J did not understand what it was aimed at, so interviewer reformulated it by giving the following options: *'How complex was it to move the emojis to each place? It was easy, difficult, super complex'*; then J answered, *'Super complex, some difficult, more or less'*.

The interviewer asked the following questions, giving the same options. J's answers were in the same style, and different degrees of complexity were mentioned in the same answer. This led the interviewer not to know how to interpret these answers.

These two experiences, which were planned to use the proposed guideline, were the first steps in exploring empathy with people with disabilities, focusing on direct interactions.

## 5 Recommendations of resources for the guideline's items

This section provides recommendations for possible resources for each guideline's item presented in Section 3.2.

The IRI test [17] is recommended for '*Choose an empathic person to conduct the empathise stage*'. There may be more than one empathic person in a team, so the whole team would have to self-assess. The objective of empathise should be considered; for example, the aim can be to train the team to acquire new skills (so-called soft skills) so that the interviewer has 'first-hand' experiences, or the focus of empathise can be to collect relevant information, and in this case, choose the most expert of the team (who is also an empathic person) interviews, or the one closest to the people the person who wish to empathise with or nearest to the disability.

To '*Generate a bond of confidence with the person who wish to empathise with*', the recommended resource is interviews to empathise, as mentioned in Section 3.2. The '*Interview to Empathise*' [15] is dynamic, as it is designed to get people (who wish to empathise with) to tell what is important to them; this, in many cases, can escape aspects of software. However, this information is precious as it can impact the use of the software. While there is an '*ideal*' interview structure, it cannot always be followed or adhered to; therefore, the interviewer should have a flexible posture when conducting the interview.

*Direct observation* can be used in the item '*Determine the predominant communication of the person who wish to empathise with*', as mentioned in Section 3.2. *Direct observation* focuses on determining how the person communicates. It can be carried out in different interactions, e.g., in an empathise interview or when inquiring.

Table 4 presents three recommended resources for the item '*Learn about the disability of the person who wish to empathise with*', such as a *Bibliography*, *Third-party consultations*, and *Direct observation*.

Three recommended resources are listed in Table 5 for the guideline's item '*Determine what resources to use to empathise related to the software that want to design*'. These resources are *Prototypes to Empathise*, *Ad-hoc generated resources to Empathise*, and *Inquiry Questions*.

The recommendations provided in this section are based on existing literature, but they are enriched by the acknowledgement achieved from the two experiences described in Section 4 and the experiences conducted in [7]; all these experiences were performed using our conceptual framework of DT for designing accessible software from scratch. In addition, all these experiences involved direct interactions with people with disabilities to empathise.

**Table 5.** Recommended resources for the guideline's item *'Learn about the disability of the person who wish to empathise with'*.

Resources	Recommendation
<i>Bibliography</i>	While it broadens general knowledge, it cannot be taken as the only source, as each person has particularities. It can be combined with active listening and direct observation to tailor the data collected to the person with a disability who wish to empathise with.
<i>Third-party consultations</i>	Consulting with third parties can provide guidance, but they are complementary, and it must be considered that the experts offer data from their own perspective, which may be biased.
<i>Direct observation</i>	Direct observation is considered essential to making personalised adjustments. However, the interviewer interprets that observation, which must constantly be rechecked because it may be biased.

**Table 6.** Recommended resources for the guideline's item *'Determine what resources to use to empathise related to the software that want to design'*.

Resources	Recommendation
<i>Prototypes to Empathise</i>	Prototypes allow interactions and observation of people in action to see their use, which provides more realism. These can be existing applications used as they are, or their use is re-signified for a particular purpose. In addition, these prototypes could be created from scratch for an empathise experience; however, this is time-consuming, and it should not be forgotten that this is discarded.
<i>Ad-hoc generated resources to Empathise</i>	These resources could be static mock-ups, which could be used to analyze visual aspects. They are generally easy to design/assemble and not very time-consuming. They can be used to investigate something that does not exist. It is essential to consider that this resource for empathising is then discarded, so it is advisable not to invest excessive time in generating it.
<i>Inquiry Questions</i>	They could use it to inquire about a prototype to empathise or an ad-hoc generated resource to empathise. Based on what is to be asked, each question is formulated, e.g. about colour as in [7] or complexity as presented in Section 4.

## 6 Discussion

This section discusses the design of accessible software from scratch. Choosing an empathic person to lead the experience is not a common consideration in DT [5]; however, we have identified that when interacting with people with disabilities, this skill becomes fundamental to actively listening to their needs. On the other hand, building a bond of confidence with the person who wish to empathise with is essential to laying the foundations for all the following interactions.

Determining the predominant communication of the people who wish to empathise with is another fundamental aspect; in our experiences, this was done through '*Direct Observation*'. In the case of J, the interviewer detected that J was constantly dispersed, which required the interviewer always to have a flexible posture. On the other hand, T's situation was different because the interviewer knew how T's disability impacted T's speech and writing; the communication started using WhatsApp and went smoothly, and then Google Meet was tried with subtitles activated. However, Google Meet was not helpful because the tool could not decipher what T was saying; this led to the decision to collect the answers to the questions about using gestures via WhatsApp so that T could express without any barriers.

It was reflected that we would have needed to enquire more initially about Down syndrome (in the guideline's item '*Learn about the disability of the person who wish to empathise with*'); this was evidenced by the ambiguous responses obtained from J (in Section 4). After the experience with J, the interviewer consulted again with the third parties mentioned in Table 1, identifying that complexity can be abstract even when given options in the question. In addition, in these chats emerged the importance of observation and repetition for people with Down syndrome to incorporate or use something new, which aligns with the benefits of gesture training mentioned in [13]. An aspect to reflect on is that the first impact of the person with the software is often given more value; however, with people with Down syndrome, training should be considered a positive aspect.

It is important to note that T did not find it challenging to perform the gestures discussed in [14], i.e., each person has different needs. This makes it clear that further exploration of empathy is required to gather what adaptations need to be considered when designing accessible software.

On the other hand, when the existing literature is analysed, it becomes apparent that most case studies start from scratch. This leads to thinking about having a *catalogue of direct empathisations* about different disabilities to have a knowledge base. This catalogue should be enriched with each new empathise experience, adding resources and detailing successes and errors, which would allow for prior consultation, and then, with all this baggage, carry out the personalised empathise stage. It is essential to mention that a significant difference between the *catalogue of direct empathisations* and good design practices or usability guidelines is that the latter generalises common aspects to be considered in the design. In contrast, the *catalogue of direct empathisations* would aspire to identify the wide variability of people's needs, especially those of people with disabilities.

## 7 Conclusions and Future Work

The design of accessible software from scratch, it becomes essential to incorporate appropriate resources to empathise with people with disabilities and identify their real needs, such as '*Interview to Empathise*' [15] or '*Prototype to Empathise*' [15]. In this sense, our empathising guideline focusing on direct interactions with people with disabilities could be beneficial. In addition, we hope this work will help reflect on the issue

and 'think outside the box' when approaching this kind of design. For example, in many cases, specialised applications are not required to establish communication, but with good observation, it is possible to detect and take advantage of what the person already uses regularly, as was the case of T with WhatsApp. Another change in mentality is about the usual conception of software testing without initial bias, as training can be very positive with people with Down syndrome [13].

This paper could contribute to reflecting on how to test software with people with disabilities since, in many cases, applications are tested by third parties, who decide on their usefulness [8].

In the future, we will continue to explore empathy with more people to enrich the recommendations of the proposed guideline and address the other two stages of the conceptual framework of DT for designing accessible software from scratch.

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