Usability of a Mobile Application for Teaching Braille to People with Visual Disabilities

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Abstract

Today, where information and communication play a central role, it is essential to ensure that visually impaired people can develop their skills in the Braille system. This gives them a powerful tool to access knowledge, communicate knowledge, communicate efficiently, and participate actively in daily life. This paper documents the development of the mobile application called Vide, which is focused on teaching the tactile Braille reading and writing system to visually impaired people, using the agile framework Scrum, having the requirements specification, design, and construction as part of the development cycle. For the validation, the proposed "System Usability Scale" tool was used to validate the purpose of knowing the appreciation in terms of usability that the selected users that the selected users have in the interaction with the application. In the application, a similar percentage of user satisfaction is evidenced. Satisfaction.

Keywords

Mobile application, teaching, visual disability, braille, usability

1. Introduction

Today, where information and communication play a central role, it is essential to ensure that visually impaired people have access to the tools they need to develop their skills and participate fully in daily life. One of these tools is the Braille system, which enables visually impaired people to access knowledge and communicate efficiently.

Globally, statistics reveal a significant gap in access to Braille. According to the World Health Organization (WHO) [1], at least 2.2 billion people globally have near or distance vision problems. In at least one billion of them, visual impairment could have been avoided or has not yet been addressed. However, only a small percentage of these people have braille skills, which limits their ability to read, write, and communicate independently.

In the context of Latin America, the figures also reflect this problem. According to the World Blind Union, the region has one of the lowest Braille literacy rates, which hinders access to education and information for people with visual impairment [2].

In the specific case of Peru, data from the National Institute of Statistics and Informatics (INEI) indicate that 801 thousand people are permanently limited in their vision, even when wearing glasses. Of this total, 52.6% are in urban areas and 44.8% in rural areas [3]. However, previous studies reveal an urgent need to promote the learning and teaching of Braille in the country.

The Braille alphabet is a tactile representation of alphabetic and numeric symbols that uses dots so that people with visual impairments can recognize it to enable them to read, write, and communicate. Despite the importance of braille for people with visual impairment, few studies

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explore technology to facilitate braille literacy. Some of this work is for using Braille with mobile applications to support literacy skills in [4] [5].

In this paper, this issue is addressed from the perspective of the development of the mobile application and its usability, which focuses on teaching Braille to people with visual impairment. It is expected to foster independence and inclusion of people with visual impairment, empowering them to develop their skills and communicate effectively in an increasingly digital society [6].

The mobile application will be implemented in Android Studio Flamingo 2022.2.1, which aims to facilitate the learning of Braille language to people with visual impairment. This tool allows users to learn interactively and practically, using their mobile device as a teaching platform. The application has a simple and intuitive interface designed so users can learn Braille autonomously and progressively. The program has exercises and activities so that the user can practice reading and writing this language and a feedback system that will allow them to know their progress.

The application is designed to be accessible and adaptable to the needs of each user. For example, voice and sound options can be configured so that the user receives verbal instructions and auditory feedback. In addition, it has a virtual braille feature that allows users to practice without needing a specialized device.

2. Related Work

The following are the papers most closely related to the topic of study. The article by Hoskin et al. [7] indicates that evaluations of the impact of the use of assistive devices in the academic setting of children and youth who are blind or visually impaired are needed. This systematic review evaluated the effectiveness of technology in supporting braille literacy education for children and youth.

Jones [8] designs effective and refreshable Braille displays, which describe the technical and design challenges faced by developers of refreshable Braille displays, which are mechanical devices that communicate Braille characters on a raised dot matrix that visually impaired users can read.

Anderson's paper [9] looks at the world's first cell phone with a Braille display, developed by an Indian company called Kriyate. Here, he describes the functionalities and features of the phone, including a 6-dot Braille display, a camera for taking pictures, and a messaging application that allows users to send and receive messages in Braille.

On the other hand, Wagh et al., in their paper "E-Braille-a self-learning Braille device" [10], describes the development of a stand-alone Braille learning device for visually impaired people, which consists of a Braille matrix that is updated by the user's input of text, and speech recognition software that guides the user in creating new Braille characters. The solution is designed in such a way as to optimize the cost and speed of operation of the device.

In the article by Zeinullin and Hersh [11], they explain how visual impairment can create barriers to accessing information in a visual format and how assistive technology has been developed to solve this problem. A system has been made that includes pre-labeled tactile graphics, an interactive web-based labeling tool, and a mobile application that provides audio descriptions for the graphics. The purpose of the application is to enable visually impaired people to obtain information without visual aids. A study was conducted to evaluate the system, which included a structured interview, quantitative measurements, and a post-experimental session to gather feedback. The study results showed that the proposed mobile application allows users to explore graphics more efficiently. Finally, there is the article "Game-Based Literacy for blind people," which explains a prototype that was designed to teach the Braille alphabet to blind people with a video game technique; this includes an extra module that can be connected via Bluetooth to the application, the system generates a set of letters and emits a sound of the letter to through the speakers of the telephone and the module displays the letter, so that the student can identify it.

Kausar et al. [12] present a novel automatic Braille character recognition approach. The designed method works in two main stages. In the first stage, image alignment and enhancement are performed using various image preprocessing techniques. In the second stage, character recognition is performed using a lightweight convolutional neural network (CNN). The proposed model shows 95.2% and 98.3% prediction accuracy, respectively. The reported testing time of the model is approximately 0.01 seconds for English images and 0.03 seconds for DSBI Braille images. The Backend as a Service (BaaS) provides a database in the cloud to store and manage information related to the application's users. This includes their progress in Braille exercises [13], configuration preferences, and other relevant data. Choosing a BaaS with scalability ensures that the application can handle growth in the number of users and the amount of data stored without compromising performance. Firebase BaaS [14] provides authentication and user management services, allowing users to register, log in, and maintain personalized profiles. This ensures the security of user information and facilitates data synchronization across different devices. In addition, BaaS provides functionalities such as access permission management and password recovery, simplifying the implementation of these critical features in the mobile application.

Lutfun, Sulaiman, and Jaafar [15] present an educational software based on the Android platform for visually impaired students. They designed the software to give users vibration and audio feedback in response to their inputs. The developed interfaces were evaluated by six advanced students, three experts, and three teachers through questionnaires and by 30 visually impaired people after using the software. Overall, the results showed that all respondents rated the software higher than 4.30 out of 5 on all usability criteria (efficiency, learnability, memorability, error, and satisfaction).

3. Materials and Methods

For the development of the mobile application based on the Braille language for blind people called VIDE, it has been decided to use the agile methodology Scrum[16].

The Scrum methodology is suitable for complex and dynamic projects, where the customer and the development team work together to adapt to changes in requirements and the environment. In addition, Scrum focuses on the incremental delivery of functional software, which allows the team to obtain early feedback from the customer and adjust the project accordingly. This is shown in Figure 1.

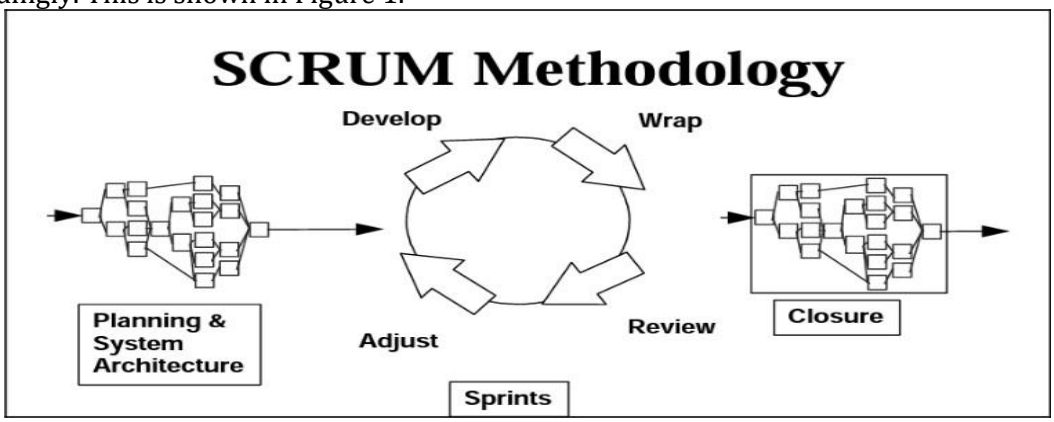

Figure 1: Scrum Methodology [16].

3.1. Project planning

In this phase, the project's objectives are aligned, trying to focus on what we want to achieve and not to reach other goals. The team was set up to establish the project's main objective and identify the application's requirements and key features. The Product Backlog, a prioritized list of items we need to develop, has been created. A multidisciplinary team that includes developers, designers, and accessibility experts. We have the Scrum Master, who will guide us through the

process, and a Product Owner, who will represent us and the users' needs and manage the Product Backlog.

The main functionality of the system is to provide a mobile Braille learning application designed for Android devices. The application allows people with visual impairment to learn and practice Braille language in an interactive and accessible way through their mobile devices.

The objectives of developing the Braille learning application are as follows:

1. Facilitate access to Braille language learning for the visually impaired, providing an interactive and practical tool on their mobile devices.
2. Provide a simple and intuitive interface that allows users to learn autonomously and progressively, adapting to different skill levels.
3. To offer exercises and activities that allow users to practice reading and writing in Braille, strengthening their skills in this language.
4. Implement a feedback system that allows users to monitor their progress and receive immediate feedback to correct errors and improve their learning.
5. Comply with accessibility standards to ensure the application is accessible and usable for the visually impaired.
6. Promote inclusion and equal opportunities by providing a tool that facilitates the learning and mastery of Braille.

The Braille learning system users are people with or without visual impairment who wish to learn and practice the Braille language using the mobile application. The report is aimed primarily at users with little or no prior experience using Braille and looking for an accessible and effective tool to acquire Braille skills.

3.2. Sprint Planning

In each sprint, defined as two weeks, they meet to plan, select the highest priority items from the Product Backlog to be addressed during the Sprint, and set a specific goal to be achieved.

Next, in Table 1, the navigability requirements are presented. These allow a comfortable and ergonomic experience for the user who, due to the visual impairment they may have, the application should have an intuitive and easy-to-use navigability.

Table 1
Navigability Requirements

Requisition Number	Name of request	Description	Type	Source of the request	Priority of the requirement
RF-1.1	Large button size	The size of the buttons should cover a large area of the screen for user comfort.	Requirement	Stakeholders	High/Essential
RF-1.2	Voice assistant between menus	When entering the application and navigating between menus, it should display a tutorial guided by a voice assistant.	Requirement	Stakeholders	High/Essential

The Usability Requirements focus on the objective of the application and the purpose for which it is being carried out, as shown in Table 2.

Table 2
Usability Requirements

Requirement number	Name of request	Description	Type	Source of the request	Priority of the requirement
RF-2.1	User authenticati on	Log in and register for subsequent storage of information, progress, and feedback.	Requirement	Operational Environment	Medium/desired
RF-2.2	Learning section	Section where the user can learn the language.	Requirement	Operational Environment	High/Essential
RF-2.3	Practice Section	Section where the user can test and strengthen the knowledge acquired in the language.	Requirement	Operational Environment	High/Essential
RF-2.4	Progress Statistics	Users should be able to monitor their learning and see its evolution over time using progress statistics.	Requirement	Operational Environment	High/Essential
RF-2.5	Immediate feedback	It should provide immediate feedback to help users correct errors and improve their learning.	Requirement	Operational Environment	High/Essential

3.3. Development of Sprints

We focus on developing the selected features during each of the Sprints. The work is divided into smaller tasks and assigned to team members. Daily Scrum meetings discuss progress, challenges, and upcoming tasks, maintaining constant and collaborative communication.

It is essential to highlight that the system has been designed with the specific needs and characteristics of visually impaired users. It provides an intuitive interface, accessibility options, and adaptability to different levels of ability in Braille learning. The goal is to provide an inclusive and satisfactory user experience for all users involved in the Braille learning process.

As for the application's design, the Figma tool [17] was used to create the mockups. First, the ideal color palette was sought, considering the need for contrasting colors so people with limited visibility could recognize them. The colors green and yellow were chosen, so the logo was designed with those colors and the letter "V" in Braille as the main image.

Next, the login interface was designed to allow the user to log in or register, considering the distinctive colors and the large font size, as shown in Figure 2. After that, the main menu briefly explains the application, showing three buttons that log out, practice and learn. Each contains different functionalities, and the last two buttons show the various learning modules.

Figure 2: Login initial and Menu Interface

Once this was done, the screens of each module were designed, and both had the option of accessing letters, numbers, and grammar signs. Fig. 4 shows the practice interface containing an additional word button, which would be the main difference between the two buttons:

Figure 3: Practice and learning interface

Finally, the keyboard screen was designed, which has a horizontal orientation for greater comfort with the user; 6 buttons are displayed representing each space in the regular braille grid, and centrally, the letter, number, sign, or word that the user must learn or practice—having as functionality the positioning of the fingers. And the other button, guide, is the quick mentoring of the alphabet, shown in Figure. 4.

Figure 4: Keyboard Interface

The functionality of the Braille Alphabet Quick Guide button is shown in Figure 5.

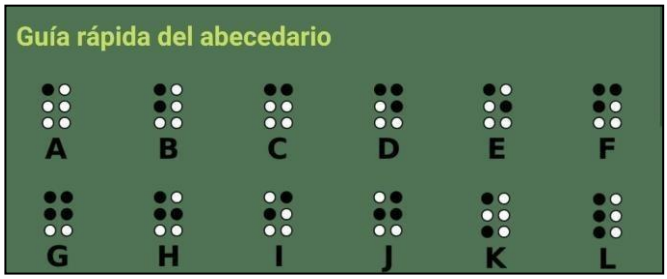

Figure 5: Functionality of the "Guide" button

For the development of the application, a new project was created in Android Studio [18] Flamingo 2022.2.1

Data persistence was performed by saving each user registered in the non-relational Firestore database [19]. For this, a new project was created in Firebase, connected to the application through Android Studio tools.

Figure 6 shows that registered users are stored in the Firestore database, including the email, ID, last name, and password fields. 7.

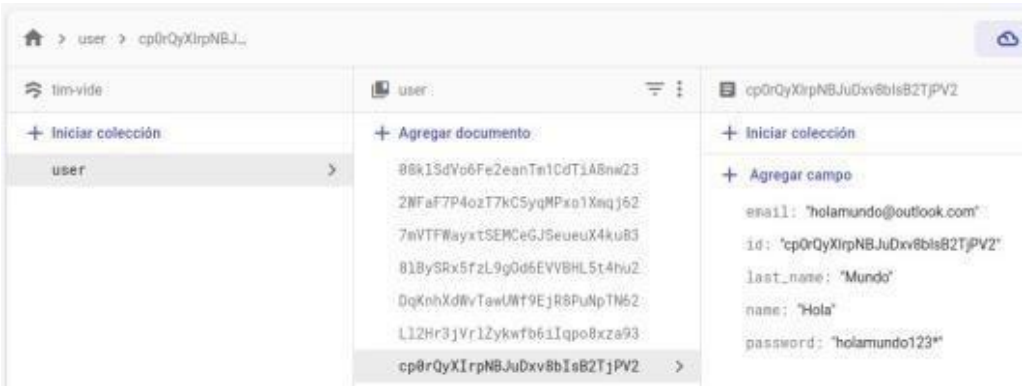

Figure 6: Database in Firestore

User registration is done through the application interfaces, to which modifications were applied to send the content of each input to the database.

Figure 7: User registration interface

Once a user is registered, they can access the application through the Login interface. The necessary changes were also applied to these interfaces to verify the registered credentials correctly. Likewise, the Firebase Authentication tool [20] was used so that users can authenticate through their registered e-mails and any Google accounts.

Figure 8 shows the list of users with credentials registered in the application's database.

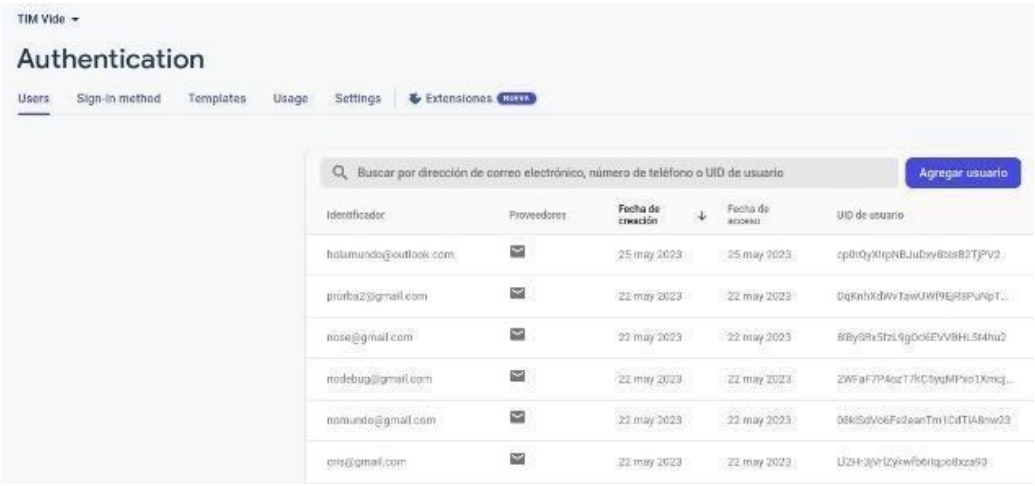

Figure 8: View of authenticated users

Access and verification of credentials is done through the login interface in the application.

3.4. Sprint Review

A review meeting is held at the end of each sprint. The completed work is shown to the Product Owner and relevant stakeholders. We collect their feedback to improve our product and development process continuously.

During this period, the development team has focused on implementing new functionalities and making improvements based on the feedback received. Below, we highlight the key points that have been addressed:

- Feedback and Improvements:
  - Improvements have been made to the feedback system to provide users with more detailed and valuable comments on errors made in the exercises, helping them to correct their Braille reading and writing skills.

- We adjusted the user interface to improve the usability and overall accessibility of the application based on user feedback and suggestions.

- Integration of additional tools:
  - A quick guide to full Braille characters has been added, allowing users to look up and obtain definitions of Braille terms.

A set of practical examples of Braille use in everyday situations has also been implemented, helping users to apply their knowledge in real-life contexts.

3.5. Sprint Retrospective

After the review meeting, time is taken to reflect internally on Sprint's performance. We identify what worked well, what we can improve, and how to optimize our work process. We learn from our past experiences and apply improvements in future Sprints.

4. Results

This section shows the results obtained; for this, a Usability questionnaire called "System Usability Scale" (SUS) [21] was used to test the level of ease of use of the software. Usability is a technique for testing or measuring software applications that is viewed from five aspects: learnability, efficiency, memorability, errors, and satisfaction.

As shown in Figure 10 and Figure 11, a similar percentage of user satisfaction is evident as items in disagreement.

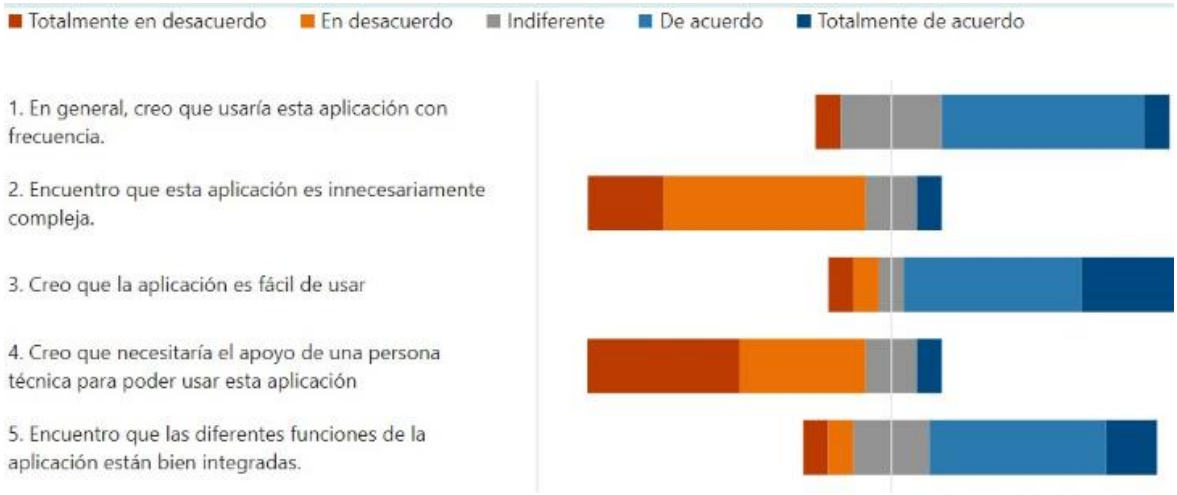

Figure 10: First part of the results

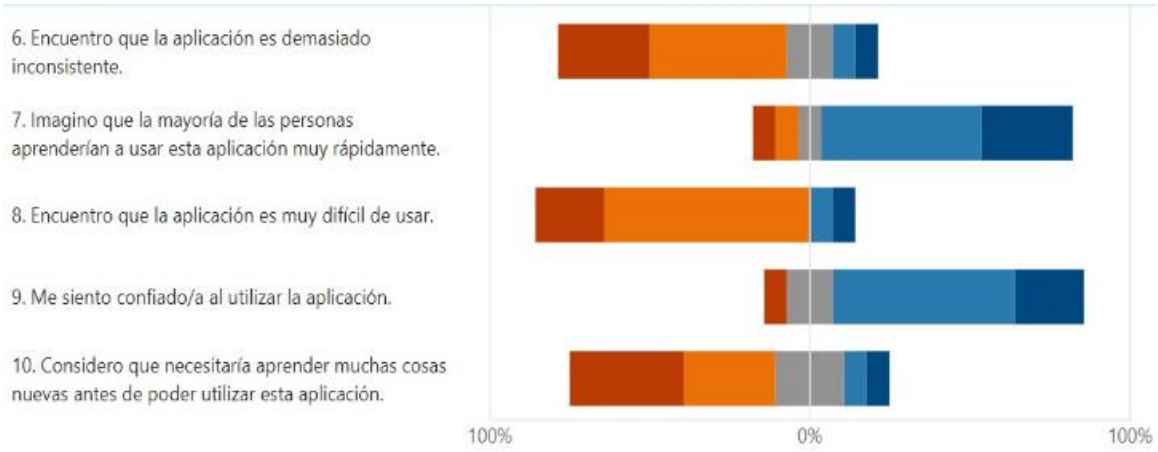

Figure 11: Second part of the results

With this feedback, we plan to improve, add more exercises, and implement an excellent database of activities and words.

5. Conclusions

The development of the VIDE mobile application using the agile Scrum methodology has been highly successful. Implementing this methodology has allowed us to achieve outstanding results in terms of accessibility and effectiveness so that visually impaired people can learn the Braille language effectively.

The application has been designed and developed considering the specific needs of visually impaired users. Thanks to this, we have created an inclusive learning experience, providing users with the necessary tools and resources to master the Braille language.

Collaboration and effective communication among team members have been critical elements in the success of this project. Constant and open interaction has allowed for efficient problem-solving, knowledge sharing, and a clear focus on the project's success. In addition, the involvement of stakeholders and users has been fundamental to obtaining early feedback and ensuring that the application meets their expectations and needs.

Frequent iterations and early feedback have been critical elements in our agile approach. These practices have allowed us to make constant adjustments and improvements throughout the development of the application. As a result, we have been able to adapt the application according to emerging needs and ensure that it meets the required quality standards.

In future work, expanding the number of exercises and implementing the database of activities and words is recommended.

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