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DESIGN AND IMPLEMENTATION OF AN ARABIC BRAILLE SELF-LEARNING WEBSITE

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Abstract

Blind and visually impaired people have long used assistive technologies, such as Braille, to aid them in their day-to-day lives. Given the importance of communication for these individuals, the ability to self-learn Braille through a specifically designed educational system is crucial for unlocking the ability to communicate while saving time and money. This paper focuses on the "learn-by-my-hand" system used to teach Braille in an Arabic context through an e-dashboard on a self-guided website. The system, which also aids sighted people, is based on content from the Saudi education ministry, allowing users to learn Braille throughout school courses. It is thought

to be the first system of its kind designed to be deployed in schools. The future work will focus on conducting a quasi-experiment study involving students with vision impairment in elementary schools, collecting both qualitative and quantitative data to evaluate the effectiveness of the proposed website. By addressing usability, user satisfaction, and its impact on academic performance, we aim to comprehensively understand the website's impact on blind students' educational experiences.

Keywords

Arabic Braille, Assistive Technology, Disability, Blind, Learning Braille, Visually Impaired.

1. Introduction

Since the Braille cell development by Louis Braille in 1824, Braille has been a critical tool in enabling blind and visually impaired people to read and write. The system, which works through raised dots representing different characters, was first designed in French but has since been expanded to capture languages across the globe. Each Braille cell contains six dots organized, as shown in Figure 1.

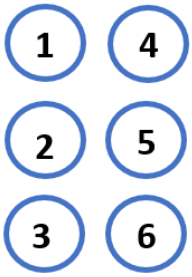

Figure 1: *Braille Cell*

(Source: Authors Own Illustration)

Approximately 285 million people worldwide are blind or visually impaired. Based on figures by the International Council for Education of People with Visual Impairment (ICEVI), around 90% are in financial poverty. Furthermore, more than half of visually impaired children are not currently engaged in formal education.

Mobile technology is an integral part of everyday living and can increase functionalism by serving as a learning aid for special needs groups (Allafi and Newbury, 2021). Blind and visually impaired individuals rely on assistive technology to aid them in their day-to-day lives and help them learn Braille, which is essential for learning and communicating. However, despite this,

many individuals may fail to learn Braille because they struggle to find appropriate resources to assist them and because learning Braille consumes too much time.

Using a website in learning media increases the students' motivation and self-efficacy, which should aid their learning process (Dirgantari and Susantiningdyah, 2021). While many online self-learning systems exist to help sighted people learn how to read and write, equivalent platforms for blind and visually impaired individuals are fewer. This is particularly true in non-English languages, as well as in developing countries (Tang, 2013).

While such systems are welcome, evidence suggests these platforms have clear limitations. According to (Kim, 2018), the website was selected as a medium because it is thought to increase motivation and self-efficacy, which should aid in their learning process, complexities and inefficiencies related to feature usability, as well as failures to overcome system errors, account for 71% of the problems users face in using assistive technologies. Furthermore, many self-guided platforms designed to teach Braille are expensive, impractical, and ineffective.

Several systems for self-learning Braille are available. These include computer-free programs utilizing standalone devices that provide verbal feedback, as well as apps that can be used either online or via a smartphone. However, very few of these systems support multiple languages. After assessing various systems aimed at individuals who are blind, visually impaired, or sighted, the researchers found clear divergences in terms of ease of use and enjoyment levels. Even though some programs do offer learning in multiple languages, systems that support either Arabic or English, or both, were evaluated in the research. Platforms in English outnumbered those in Arabic.

Research uncovered that there are currently no online self-guided Braille systems in Arabic nor any apps designed for official school courses. In light of these findings, this paper aims to correct this issue by creating a website that works across multiple platforms to allow users to learn Arabic Braille independently. The system is designed to enable students to learn the first class from the official course of a Saudi Arabian elementary school. The content will therefore be based on the official curriculum provided by the book of the Ministry of Education. The system's interface is also designed to suit sighted individuals of any age, increasing its applicability. In addition to its educational purposes, the website aims to support both students and their families to learn Braille without additional assistance. Furthermore, by enabling self-guided learning, the system will reduce the burden on Braille teachers in formal education contexts. The website will

be structured through a dashboard design that enables additional courses from the "لغتي my language" book (Ministry, 2021) to be added later. To begin with, however, only the first level in elementary school is included.

The remaining sections of the study are as follows: Section 2 provides a literature review, and Section 3 gives a detailed illustration of the Learn-by-my-hand system. Finally, a conclusion and discussion regarding future research opportunities are detailed in Section 4.

2. Literature Review

Current self-guided systems for learning Braille, including online, smartphone-based, and standalone platforms, have been studied in depth by Alsalman et al. (2022) to improve various programs. Generally, developers of web-based systems aim to produce platforms that can operate across specific computer designs and operating systems. Examples of such English-based programs include eKodBraille (Lee et al., 2015) and the e-learning program for Braille (Takaoka et al., 2011). These two systems are both aimed at sighted users.

Al Saleh and Al-Salman (2012) created Al Wafa, a software program designed to teach Braille to individuals who are both sighted and blind. Other systems, like Blind Aid (Khidri et al., 2014), offer a low-cost option for self-guided learning by translating inputted documents or words typed on a Braille keyboard by verbalizing or displaying the content. Another system, Onto Braille @RID, supports blind people in their efforts to independently learn Braille in either English or Chinese (Tang, 2013). This platform offers both practice sections and formal exams.

Standalone self-guided learning platforms include the Spoken Dialogue System (Araki et al., 2011), Braille Writing Tutor (BWT) device Dias (Dias et al., 2009), E-Braille (Wagh et al., 2012), a one-cell Braille tutor (Aizawa & Watanabe, 2014), and Braille Tutor (Joshi & Samasgikar, 2016). These platforms help users learn English, except BWT, which teaches Hindi.

Braille Instructor (Al-Watban, & Al-Salman, 2019), learn Braille with Nouf (Mont Asser, 2020), BrailleEasy (Qatar Computing Research Institute, 2015) (Šepić et al., 2015), and touch Braille (R. & A., 2017), are all examples of smartphone apps designed for IOS-based devices. The first three systems teach Braille in Arabic, while the other two teach English. Braille Instructor is explicitly aimed at blind and visually impaired individuals. BrailleEasy supports both sighted and visually impaired people, while Learning Braille with Nouf and Touch Braille are oriented exclusively toward sighted people.

Aprende Braille (Mario Ugedo, 2020), Learn Braille: Beginner Guide (USEFUL APPS, 2018), Learn Braille (Mario Ugedo, 2020), Braille Helper (Kumar, 2021), and. Braille Tutors (Brailliac, 2018) are all examples of Android-based systems designed in English for sighted individuals, although Braille Helper also supports visually impaired people. In addition to English, Braille Tutor and Aprende Braille also support Swedish and Spanish, respectively.

Applications that support both Android and IOS devices include Braille Academy (Learn and Train, 2020), Taptilo+ (Smart, 2020), and Taptilo U (Smart, 2018). Several previous studies have sought to design a Braille cell that can be implemented in self-guided learning systems for Braille (Jawasreh et al., 2020; Wagh et al., '2016' Avhad et al., 2016; Wicaksono & Kurniawan, 2019; Kavalgeri et al., 2019; EM et al., 2021; Abirami et al., 2018). Rather than developing learning resources, each of these studies targeted electronic cells. Consequently, only digital numbers and letters were programmed.

3. Learn-by-my-hand System Design and Implementation

While several self-learning Braille apps lack the sophistication to support educational standards, there is a lack of research into these systems' educational impact. The current platforms' simplicity means they fail to take into account teacher-student communication, focusing instead on limited processes designed to teach numbers, letters, and basic sentence construction. This study seeks to add this link, allowing teachers and students to engage in learning by setting and completing examinations. The system will also allow students to go back over previous concepts independently. At the same time, parents of blind children will be able to gain insight into the areas in which their children are strongest and weakest. In addition, each student signs up using email, allowing teachers, school administrators, and student parents to contact each other. Based on existing research, this will be the first example of such a system for teaching Braille in Arabic.

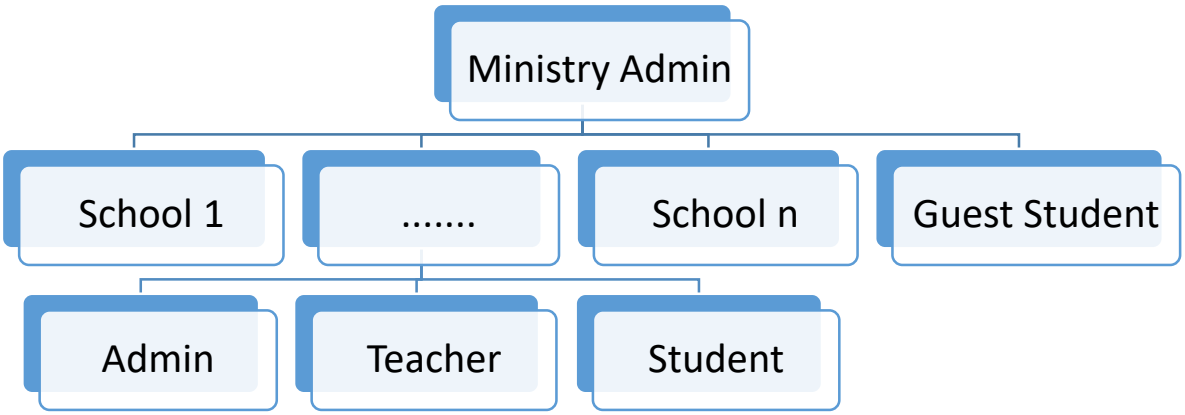

Figure 2: *The System Users*

(Source: Authors Own Illustration)

Three forms of control are described on the Learn-by-my-hand system online page. The first is ministry administrator control, which involves the administrator overseeing school courses and staff on a national level. The Ministry administrator is responsible for adding, editing, or removing the schools' information, such as the teachers, school administrators, and lessons from the dataset. The second type of control is school administrator control, through which the administrator in question oversees students and teachers. The school administrator can create and edit the teachers' and students' accounts. The final type, teacher control, allows teachers to guide their students in their lessons and exercises, and monitor their progress. Anyone seeking to learn Arabic Braille using the website can access it without formal registration; however, their data will not be preserved in the database, and they cannot review previous lessons. All school courses are offered in Braille on the platform, enabling blind and visually impaired students to fully engage in the educational process. The hierarchy of user control regarding the system is outlined in Figure 2.

3.1. The System Content

Supporting blind and visually impaired children to engage in level 1 of Saudi Arabian elementary school without outside support is the main goal of the proposed system. The platform uses "لغتي my language's" (Ministry, 2021) official teaching materials. This comprises three units: Braille recognition; the alphabet, words, sentences, and diacritics; and more advanced lessons based on previous learning. The first unit is designed around a book and Perkins Brailler but also allows students to seek support from Orbit Reader 20, ElBraille 14, Smart Beetle, and other Braille typing devices to improve the system's practicality. Examples of Braille typing devices are

displayed in Figure 3. The proposed system follows the official book's processes in terms of structure and content.

ElBraille 14 Orbit Reader 20 Smart Beetle

Figure 3: *Braille Typing Devices*
(Source: Collected by Authors)

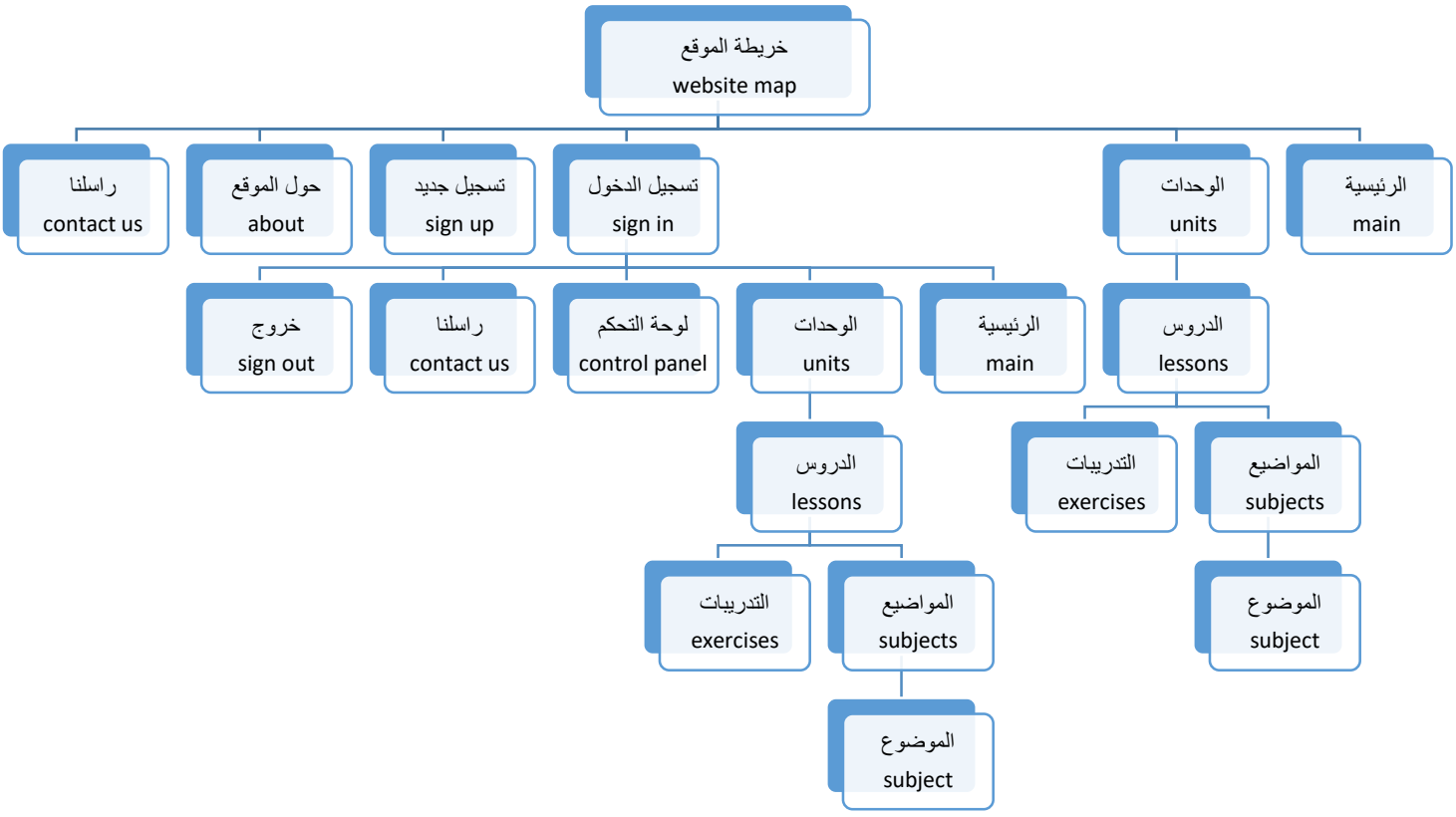

Figure 4: *Student Website Map*
(Source: Authors Own Illustration)

Slight alterations have been made to the lesson plans to increase their suitability regarding devices used to type in Braille. In addition, four extra units were included to increase the learn-by-my-hand approach's functionality. These were designed around Saudi Arabia's officially certified Arabic Braille teaching book (Textbook, 2002), "كتاب نظام برايل العربي المطور Improved Arabic Braille system book." Since not all Arabic alphabet and diacritics are included in the ministry curriculum, extra lessons are proposed in unit three to cover more alphabet and diacritics. Punctuation in Arabic Braille is outlined in unit four. Mathematical symbols and numbers are taught in unit five. Unit six focuses on abbreviations, while unit seven aims to improve students' ability to sense Braille through numerous exercises. Teachers also have the freedom to introduce additional content or exams to aid the learning process, while parents can contact the school through the system if required. A map of the student website is shown in Figure 4, highlighting the use of multiple units with their respective lessons and subject matters. The seven units comprise over 50 lessons covering 300 subjects, with at least 550 individual exercises.

3.2. Interface

While the platform is designed for anyone to use, the system needs to be simple enough for blind and visually impaired individuals to navigate the content successfully. This means limiting the number of images and including voiceover technology to verbalize the written content. A survey of 18 blind or visually impaired individuals, as well as their teachers and relatives, was deployed to ascertain the necessary design features. Developers of existing systems and individuals who are engaged with Braille learning systems also participated in this process. Of the respondents, 83.3% were fluent in Braille reading and writing. The rest had varying proficiency levels, but not to the same standard as their peers. Various questions concerning how to successfully design an online platform interface were included in the survey, with the following suggestions made:

- The platform should support screen reading
- Files need to be presented in Word format for screen-reader access
- No adverts should be featured
- Descriptions need to be provided for all menus, buttons, and images
- Ease and simplicity should be prioritized
- The system should enable blind individuals to process all the content without requiring external support

Each of these recommendations factored into the design of the resulting online platform.

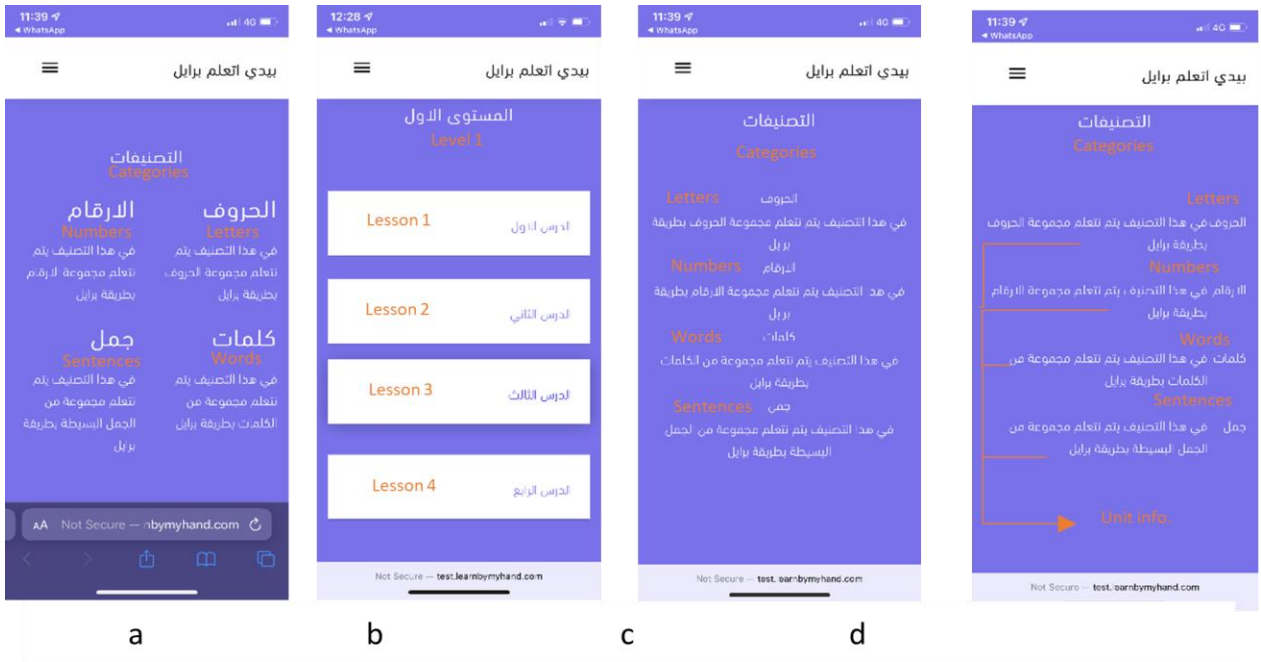

Figure 5: *Main Screen Models*
(Source: Authors Own Illustration)

Figure 6: *The Ministry Administrator Interface*
(Source: Authors Own Illustration)

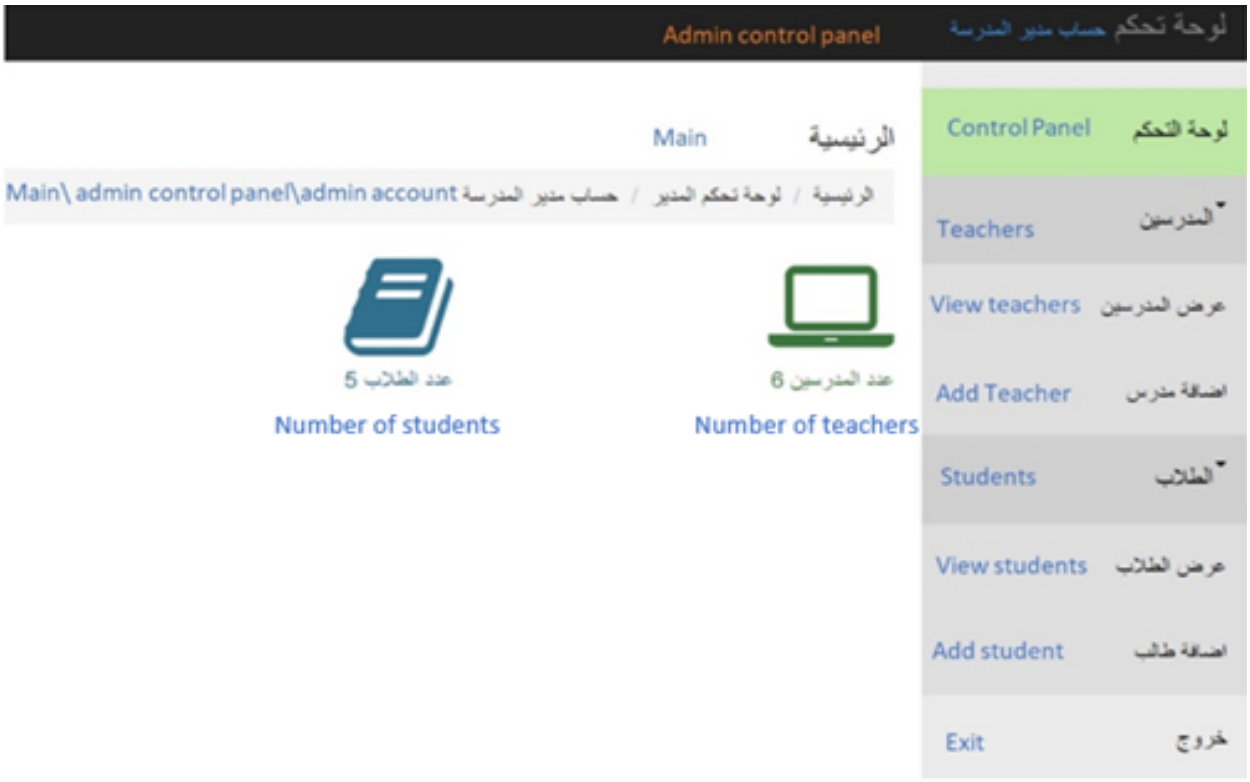

Figure 7: *School Administrator Control Panel*
(Source: Authors Own Illustration)

Figure 8: *Teacher Page*
(Source: Authors Own Illustration)

Multiple interfaces were designed, each taking the above factors into account. Six Braille teachers were then blind tested to determine which was the most successful option, with each design rated according to how the content was presented. The four main screen interfaces are displayed in Figure 5(a-d). Option b was preferred by all of the participants as the best option, which was therefore chosen. The ministry administrator, school administrator, teacher, student, computer-based, and student smartphone-based interfaces are shown in Figures 6-10. It should be noted that the administrator's interface was not designed for use by visually impaired individuals.

Figure 9: *Student Computer-Based Learn-By-My-Hand System*

(Source: Authors Own Illustration)

The system allows students with varying levels of sight to access the content successfully. For individuals with vision impairment, the option of using a screen reader allows them to have all the content verbalized. Smartphones, computer screens, keyboards, and Braille typing devices can all be used to record inputs and outputs. At the same time, sighted individuals can provide their answers without requiring additional equipment. Not relying on a smartphone or keyboard is a key benefit of using a Braille typing device, which will help to improve a student's reading ability. Learn-By-My-Hand System (https://learnbymyhand.com/) provides access to the student page.

Figure 10: *Smartphone-Based Learn-By-My-Hand System Interface*

(Source: Authors Own Illustration)

4. Conclusion

In conclusion, the learn-by-my-hand platform provides the means to self-learn Braille in Arabic without additional support or guidance. Through the use of a survey involving 18 people who are either blind or visually impaired themselves or who play an active role in supporting such individuals, a dashboard-based system was designed that enables blind and visually impaired students to access and complete all level 1 school lessons. Based on these findings, future research should seek the responses of the elementary school children for whom the platform was designed to assess its success. For further insight into the platform's ease of use and navigability, such research should also compare the responses of sighted and visually impaired individuals across different age groups. In order to evaluate the effectiveness of the proposed website for blind students, we plan to conduct a quasi-experiment in collaboration with primary schools, collecting both qualitative and quantitative data to evaluate the effectiveness of the proposed website. We

aim to provide each blind student with an Orbit Reader 20 and an iPad and observe their usage and experiences with the website. This quasi-experimental design will allow us to gather valuable insights and assess the website's impact on their learning outcomes. We aim to conduct the quasi-experimental in several ways. Firstly, we aim to conduct a comprehensive usability study to assess the website's user interface and navigation from the perspective of blind students. Through this study, we can identify potential challenges or improvement areas regarding accessibility and user experience.

Additionally, we plan to collect qualitative data through interviews and surveys to understand the students' perceptions, preferences, and overall satisfaction with the website. This feedback will provide valuable insights into the website's effectiveness in meeting the unique needs of blind students and enhancing their educational experience. Furthermore, we intend to collaborate with educators and administrators to gather quantitative academic performance and progress data. By analyzing students' performance metrics, such as test scores and completion rates, we can evaluate the website's impact on their learning outcomes and academic achievements. To ensure the generalizability of our findings, we aim to expand the study to include a larger sample size of blind students from diverse educational schools. This study, with a large size of students, will allow us to gather a more representative dataset and strengthen the validity of our conclusions.

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