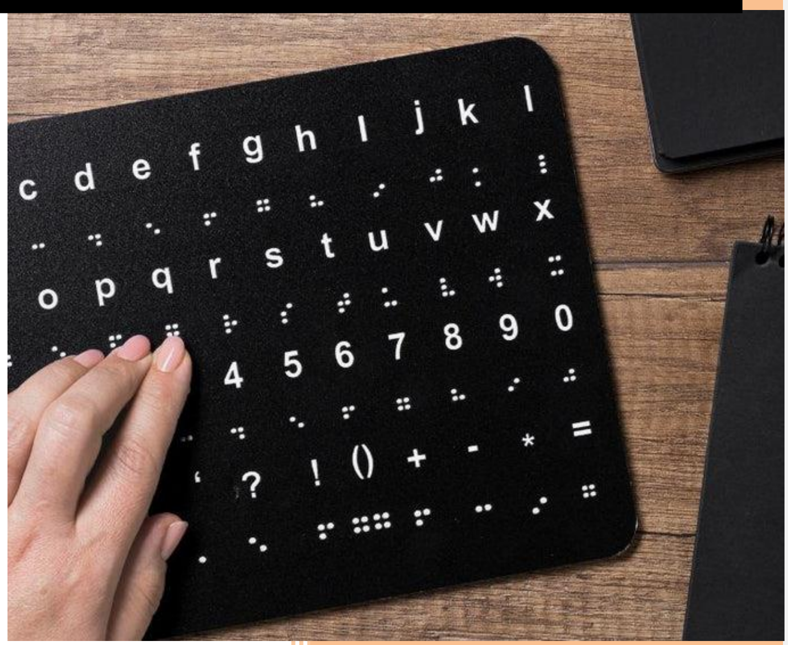
BRAILLIANT

System Architecture & Design Finals Project



Brailliant: Web and Mobile Based Refreshable Braille Display Reading Board

Brailliant: Web and Mobile Based Refreshable Braille Display Reading Board

A Capstone Project
Presented to the Faculty of
NU MOA - School of Information Technology

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Information Technology
With Specialization in Mobile and Web Applications

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March 2025

RECOMMENDATION FOR ORAL EXAMINATION

This capstone project titled: "**Brailliant: Web and Mobile Based Refreshable Braille Display Reading Board",** prepared and submitted by **Aaron Jiro D. Ropeta, Ashley R. Villanueva, Michael Joseph B. Melo, and Ysabella Shery B. Villanueva** in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Technology with Specialization in Mobile and Web Application has been examined and is recommended for acceptance and approval for ORAL EXAMINATION on ________________.

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APPROVAL SHEET

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ENGLISH EDITING CERTIFICATE

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Brailliant: Web and Mobile Based Refreshable Braille Display Reading Board

by *Aaron Jiro D. Ropeta, Ashley R. Villanueva, Michael Joseph B. Melo, and Ysabella Shery B. Villanueva* and have found it thorough and acceptable with respect to the grammar and composition using the premium Grammarly tool.

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DEDICATION

We dedicate this research paper to the people who had given us the undying support and pushed beyond our limits.

To God, Our Creator, who led us through the darkness with light of hope and guidance.

To our parents, who taught us any difficult task can be accomplished once it is done one step at a time.

To our former Capstone advisers up to the present, Capstone Coordinators, friends, and classmates. Thank you! We sincerely appreciate all the support and efforts throughout the process. May God bless us all!

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EXECUTIVE SUMMARY

Brailliant is a web and mobile-based platform integrated with refreshable braille display model designed for visually impaired students. It aims to provide cost-effective assistive technology that allows visually impaired students to interact with digital educational content using system platforms and refreshable braille display. The system features a real-time text-to-braille translation for seamless learning of the students. It also includes interactive features and integrated analytics to monitor student performance and progress. The high cost of existing RBDs is a challenge for schools to adopt them. Therefore, this project aims to provide a more affordable alternative to enhance educational opportunities digital inclusivity.

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CHAPTER I

INTRODUCTION

In the Philippines, vision impairment and blindness affect a significant portion of the population, with approximately 1.98% of Filipinos experiencing various forms of severe visual impairment [1]. Visual impairment is a broad term that describes a vast continuum of loss in visual function. It refers to conditions ranging from low vision to blindness that cannot be treated with glasses, contact lenses, surgery, or medication [2] [3]. With such a condition, a person would find it hard to perform daily tasks and essential needs independently, affecting their quality of life. Such barriers can dramatically affect children who are just starting in life and attending school but still have much to learn.

With the high prevalence of visual impairment in the Philippines, accessible technology solutions are needed to support visually impaired students in education and institutional activities. One of the assistive technology tools marketed on behalf of people with visual impairments is refreshable braille displays (RBDs). It is a tactile electronic device that uses small pins that raise and lower to generate combinations represented as braille [4]. However, current Braille display devices are found to be expensive, limiting accessibility for many, especially in schools with insufficient funding. Hence, it hinders the adoption of such essential tools in educational institutions, which prevents visually impaired students from fully engaging with digital learning materials. Addressing this accessibility gap would allow these students to enable independent digital reading, improve literacy development at a young age, and expand educational opportunities.

1.1 PROJECT CONTEXT

Accessing information, education, and communication tools was once deemed challenging for vision-impaired individuals. In today's world, it is indisputable that blind people are now relatively self-sufficient when it comes to searching for and reading articles and books presented in electronic formats [5]. With the rise of assistive technology tools such as Text-to-Speech (TTS) and Refreshable Braille Display (RBD), digital information can now be relayed quickly among these individuals.

However, such technologies that rely heavily on auditorial information come with drawbacks. While text-to-speech can improve access to information, a study by Lang et al. [6] found that the use of TTS has shown a negative correlation with Braille reading fluency and spelling skills. This study suggests that relying too heavily on auditory aids may potentially hinder the development of braille literacy skills.

Another way to balance out the use of text-to-speech is devices called refreshable braille displays (RBD). These devices are based on the tactile writing system that was developed by Louis Braille. In this writing system, characters of the alphabet are represented by raised dots in a cell of 3x2 dots or 4x2 dots. RBDs are devices wherein the raised dots change dynamically, enabling the representation of different texts within the same device. Currently, RBDs with piezo actuators are the commonly used and commercially available versions of the device. Though proven to be reliable with its moderate complexity of module mechanisms, fast refresh rate, and relatively low power consumption, Piezo-actuated RBDs are typically expensive [7] [8].

Considering the drawbacks associated with Text-to-Speech (TTS) technology and the current costly Refreshable Braille Displays (RBDs) in the market, the need for an inexpensive, timely solution arises. Without addressing these problems, accessibility to these assistive technology tools is deemed problematic. Also, the adoption of these tools can be challenging, especially in educational institutions that serve students with special needs who require extensive educational support. As a result, the students struggle to interact with digital learning content, limiting their learning opportunities.

To address these pressing needs, Brailliant provides a system platform and digital space for visually impaired students to interact with digital content along with their instructors. Integrated with an alternative and inexpensive braille display that leverages IoT technology, Brailliant focuses on functionality while considering user experience, ensuring students can access braille content seamlessly. Brailliant serves as an innovative solution for bridging the gap of accessibility to cater to the needs of visually impaired students for a better educational outcome.

1.2 PURPOSE AND DESCRIPTION

Brailliant is a web and mobile-based refreshable display system that integrates IoT technology into wireless connectivity. The system provides a device and system platform for visually impaired students to learn and engage with digital educational content in braille format. This innovation addresses the accessibility gap and provides a cost-efficient refreshable braille display.

Brailliant serves as an extension of Vijay Varada's project to develop an electromechanical refreshable braille module. In his award-winning project, he employs an electromechanical system to operate the mechanism of small pins to generate patterns represented as pins [9]. With the help of an evaluation board and programming, each module can generate the preferred braille pattern.

To further enhance Vijay's work, the researchers established a web and mobile platform that revolves around the refreshable braille display model to fully optimize and enhance the device's functionality for performance and efficiency. This integration allows resourceful functionalities between the device and system that provide digital interaction between visually impaired students and instructors.

Brailliant features a real-time text-to-braille translation. The platform visualizes the braille output presented in the device and the character it represents. The system also features integrated analytics to monitor the student's progress and performance.

1.3 OBJECTIVES

GENERAL OBJECTIVES

This study aims to develop Brailliant, a Refreshable Braille Display system integrated with IoT technology along with mobile and web platforms for instructors to use in enhancing accessibility and effective teaching for visually impaired students.

SPECIFIC OBJECTIVES

- To develop a Refreshable Braille Display board with text-to-Braille functionalities and IoT connectivity features.
- To create a content management platform that will allow instructors to add, delete, and update learning materials.
- To implement a class management system that enables instructors to manage student records and track individual performance through one-on-one guided sessions.
- To design an administrative module that allows administrators to oversee accessible educational content in the system.
- To integrate analytic tools that summarize student progress and session outcomes to support data-driven instructional decisions.
- To evaluate the system based on the following criteria:
    - functionality
    - reliability
    - usability
    - portability

1.4 SCOPE AND DELIMITATION

SCOPE

This study focuses on the design and development of Brailliant, a web and mobile system integrated with an IoT device. The project aims to enhance the learning experience and accessibility with digital educational content of visually impaired students. The system was inspired by Vijay Varada's project, which utilized an evaluation board and inexpensive components for the braille module to achieve reliable functionality and cost-efficiency for the device. It features text-to-braille conversion, interactive user interfaces, data synchronization between the IoT device and digital platforms, and monitoring learning progress through integrated analytics, ensuring that Brailliant functions as a collaborative educational tool to complement traditional teaching methods.

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DELIMITATION

This study is delimited to educational applications and restricted to instructors, system administrators, and visually impaired students as its primary users. It is not intended for full-scale production or commercialization, as it is restricted to developing and designing a functional prototype that prioritizes affordability and functionality. Thus, the incorporation of advanced features is limited compared to those found in premium refreshable braille displays.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND SYSTEMS

2.1 RELATED LITERATURE/STUDIES

VISUAL IMPAIRMENT

The International Statistical Classification of Diseases and Related Health Problems (ICD) classifies visual impairment into two categories: visual acuity and near vision impairment. Visual acuity is classified into mild, moderate, or severe distance vision impairment, including blindness, while near visual acuity is considered impaired when an individual has difficulty reading standard small print even with corrective lenses [10]. In the Philippines alone, approximately 1.98% of the population experiences visual impairment, presenting significant challenges, particularly for children [1]. Individuals with visual impairments, particularly children, are more likely to face challenges in cognitive, emotional, neurological, and physical development due to the limited experiences and access they have to various types of information [11].

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A meta-synthesis conducted by Safawi and Akay reveals that visually impaired children typically exhibit delays in language, cognitive, and psychomotor development [11]. According to the research, these children are observed to have developmental delays for about 6-12 months in their motor coordination, play behaviors, and social skills [12]. Due to these delays, gross and fine motor skills are highly affected [13], further amplifying their inability to access information, education, and communication tools and reinforcing the critical need for effective assistive technologies. These interconnected developmental challenges of visually impaired children highlight the need for developing and implementing effective assistive technologies that can mitigate these barriers and enhance learning opportunities for visually impaired individuals.

ASSISTIVE TECHNOLOGY DEVICES (ATD) FOR VISUAL IMPAIRMENT

Assistive Technology Devices (ATDs) have emerged as vital tools for visually impaired individuals, enhancing autonomy, independence, quality of life, and social inclusion. Assistive Technologies (ATs) are 'items, devices, equipment, or products which may be commercially available, customized or adapted to help a person with a disability function or improve, maintain or increase their capacity to function' [14]. In education, the World Health Organization (WHO) characterizes assistive technologies as specialized equipment, products, processes, methods, and technologies designed to facilitate the acquisition of knowledge, expertise, or skills [15]. These technologies include screen readers, magnifiers, and refreshable braille displays (RBDs), each designed to address a specific aspect of visual accessibility.

Modern research shows both the benefits of these devices and the challenges in making them widely available. Alanazi and Benlaria [16] highlight how these devices enhance functional independence for individuals with disabilities while identifying barriers, including limited access to affordable yet effective technologies. Similarly, Fernández-Batanero et al. [17] found that assistive technology devices can significantly improve educational accessibility and create a more inclusive learning environment for students that addresses their diverse needs. The findings of this study showcase how assistive technologies can simultaneously open opportunities for individuals with disabilities to gain independence and inclusion while also mitigating challenges in accessibility and implementation across educational and workplace settings.

Furthermore, studies support the critical role of ATDs for visual impairment in improving inclusion and academic skills for students. Purnomo et al. explored the adaptive technologies in library settings and inside the classroom, emphasizing how systems that vocalize text, convert printed documents to digital formats, facilitate physical navigation, and translate digital content into tactile Braille are essential for supporting visually impaired individuals [18]. In addition, Rabello et al. [19] assessed the impact of educational interventions that included eye examinations, the prescription of various optical and non-optical ATDs, and computer orientation on the performance of six visually impaired schoolchildren aged 12 to 14. Following these interventions, most participants experienced reduced reading times and improved ability to read printed text in smaller fonts. These results suggest that ATDs can significantly enhance the reading skills and overall academic performance of visually impaired students, enabling them to perform school tasks more effectively.

Overall, these studies reinforce the importance of developing cost-effective, user-centric solutions that can be integrated into educational systems to empower visually impaired students. Technologies like ATDs not only facilitate access to information but also create a more inclusive learning environment, empowering visually impaired students to engage more effectively with educational and digital content.

REFRESHABLE BRAILLE DISPLAY (RBDs), ACTUATORS, AND COST CONSIDERATIONS

Refreshable Braille Displays (RBDs) represent a specialized subset of ATDs that convert digital text into tactile Braille output in real-time, offering improved functionality and dynamic tactile feedback. RBDs enable visually impaired individuals to interact with digital content by converting text into tactile Braille output in real time. This is possible by electronically raising and lowering different combinations of pins in cells representing a Braille character. Advanced RBDs can typically output up to 80 characters from the screen and can change simultaneously with the user's cursor as they move it around the screen. Despite the significant advantages of using RBDs and other ATDs, they face several challenges in their widespread implementation, including low refresh rates, limited display sizes, and, most notably, high costs. Currently, available RBDs in the market can be prohibitively expensive, which can range from $3,500 to $15,000 [20].

A critical part of an RBD is the actuator that enables the pins to change dynamically. The type of actuator used determines the overall performance and cost of an RBD. Commercially available devices commonly use piezoelectric actuators, which offer fast refresh rates and precise dot spacing but are expensive and complex to manufacture. Chen et al. [21] conclude that RBDs made from piezoelectric actuators cannot benefit low-income visually impaired populations in developing countries, creating a financial barrier for many visually impaired individuals and educational institutions. On the other hand, electromagnetic actuators have emerged as a promising alternative, offering lower manufacturing costs, enhanced reliability, and longer service life. These advantages make electromagnetic systems potential breakthroughs for developing high-performance, cost-effective Braille displays [21].

In response, much research has emerged focusing on developing more affordable RBD solutions without sacrificing functionality. Bettelani et al. [7] introduced the Readable system, a single-cell electromagnetic RBD that delivers tactile feedback comparable to traditional paper-based Braille. However, it revealed certain design complexities and user experience challenges that indicate further innovation is necessary. Russomanno et al. [5] studies have demonstrated that single-cell displays lacking sliding contact led to poorer tactile performance and increased reading errors, emphasizing the need for multi-cell configurations to enhance tactile feedback and improve reading efficiency. Additionally, Kim et al. [22] developed a portable RBD using flip-latch electromagnetic actuators, achieving low power consumption and a compact design that illustrates the potential for advanced mechanical integration in portable devices. This study ultimately led to the development of Varada's project. Varada showcased a cost-effective approach by creating an electromechanical refreshable braille cell using Cam actuators and 3D-printed parts. From a single Braille cell that may cost around $100 to $150, Varada was able to lower the initial cost of producing a single cell to $0.82. Coupled with Varada's evaluation board, a cost-efficient RBD was created with the sole purpose of dynamically refreshing Braille characters. Our project will build on Varada's innovative methodology by incorporating his design elements into our development process, further reducing costs and enhancing performance to create an accessible and scalable RBD solution [9].

IOT-BASED ASSISTIVE DEVICES AND ITS ROLE IN EDUCATION

Education and technology have always been crucial in creating a more inclusive learning environment. The increasing demand for assistive technological tools in education highlights the importance of breaking down barriers in learning and accessibility. Recent research shows that integrating Internet of Things (IoT) technologies into assistive devices has the potential to revolutionize educational experiences for students with disabilities, specifically for visually impaired students.

Bansal and Garg [23] explored different IoT applications in assistive devices for navigation, communication, and education. They illustrate how smart devices can enable disabled students to control campus facilities and enhance their overall educational experience. Rodrigues [24] further establishes that IoT-based systems that include the conversion of digital text to accessible formats such as audio or Braille can improve access to learning materials for visually impaired students. McRae et al. [25] stress the importance of embedding IoT technologies within existing learning management systems and providing comprehensive training for educators and students. Additionally, a systematic review by Wambua and Oduor [26] reveals that IoT can significantly improve accessibility and personalized learning; however, the researchers took a strong stance that there are still significant gaps in ensuring seamless access and fairness to persons with disabilities.

The studies mentioned further highlight the need for collaborative efforts among educators, developers, and policymakers to create inclusive and effective IoT solutions. These studies establish the need to develop innovative, IoT-based assistive technologies like RBDs that can significantly enhance educational accessibility and improve the learning experience and outcomes for visually impaired students.

2.2 RELATED SYSTEMS

Table 1. Gap Analysis Table of Related Braille System Applications

System Applications	Text-to-Braille	Text-to-Speech	Content Management	Analytics
BrailleBuzz		✓		
BrailleBlaster	✓			
JAWS (Job Access with Speech)		✓		
Brailliant	✓	✓	✓	✓

Table 1 shows the list of applications that were related to this study. Different apps were studied and compared based on the following features.

2.2.1 BrailleBuzz

BrailleBuzz [27] is an instructional tool designed for young braille learners with visual impairment or blindness. It features a full Perkins-style braille keyboard with numbers and audio feedback, providing users an interactive and engaging learning experience. The tool also comes with a software application that provides functionality to the BraileBuzz hardware device.

2.2.2 BrailleBlaster

BrailleBlaster [28] is a functional translation software designed to translate text into a braille format, primarily for editing textbooks into braille format. It essentially converts written content and mathematics into a format that can be read by people who are blind or visually impaired using a braille display. With its flexibility, BrailleBlaster supports direct output from a braille printer or embosser and the conversion of text from standard computer format into an interim braille file.

2.2.3 JAWS (Job Access with Speech)

JAWS [29] is a widely used screen reader for blind and visually impaired users to access and interact with digital content through text-to-speech output or a refreshable Braille display. As the most popular screen reader, JAWS enhances accessibility by providing speech and Braille support for various applications, allowing users to navigate the internet, write documents, read emails, and create presentations from anywhere. It provides accessibility for most used computer applications on the computer. Primarily, it focuses on providing support on software applications used in corporate environments, such as Access and Excel, earning its reputation as a preferred screen reader for blind and visually impaired people who work in larger organizations.

2.3 SYNTHESIS

Education and technology have long worked together to create accessible learning environments. The reviewed systems showcase the current progress and shortcomings in existing Refreshable Braille Display systems. Applications like BrailleBuzz, BrailleBlaster, and JAWS offer invaluable features in improving accessibility to users, such as text-to-Braille conversion and text-to-speech (TTS) [28] [29] [27]. However, these applications generally address only certain aspects of accessibility. It is clear from these reviews that there is currently a lack of RBD systems that function holistically and toward the diverse needs of visually impaired students. Studies have shown that technology can enhance the learning experience of students with disabilities, promoting independence and opening new avenues for personal and academic success [16].

On the other hand, IoT devices hold the promise of advancing educational technology even further. Despite the lack of affordable RBDs in the market, researchers are actively working on creating practical solutions to overcome this barrier. The works of Chen et al. [21], Kim et al. [22], Bettelani et al. [7], and Varada [9] show that accessible IoT devices are evolving and emerging. These studies encourage further exploration into integrating IoT technology with software systems to create truly accessible environments for visually impaired users.

These studies justify the need for an integrated, cost-effective platform where all critical functions converge, such as text-to-Braille conversion, text-to-speech, content management, and analytics. Our proposed system, Brailliant, will build on the insights from current systems and specifically incorporate IoT technology to enable real-time interactivity and connectivity. By doing so, it addresses the shortcomings of existing systems and provides a scalable, user-friendly solution that can enhance educational accessibility for visually impaired students. This approach not only fills a significant gap in the current technology landscape but also lays the groundwork for future innovations that further improve learning outcomes and digital inclusion.

CHAPTER 3

TECHNICAL BACKGROUND

3.1 DETAILS OF THE TECHNOLOGY TO BE USED

The researchers proposed the development of Brailliant, a platform aimed to support the education of visually impaired students through accessible and affordable assistive technology. The goal of this project is to bridge the gap in digital inclusivity for VIP students and educators by providing ways to utilize affordably made RBDs with an accessible learning system such as Brailliant. Paired with an affordable RBD device and Brailliant, the system can potentially enhance the overall learning experience of the students especially in learning Braille by including real-time text-to-Braille translation, content management tools for instructors, and performance analytics to monitor progress.

SOFTWARE

Table 2. Software Requirements

Software	Specification
Windows Operating System	Windows 10 is the minimum specs requirement for all the languages to be installed in the PC.
Mobile Application	
Android Studio	At least 2.0GHz processor with at least 2GB of RAM and at least have 2GB of available disk space to install.
Adobe Illustrator	With at least 2GB RAM and at least have 2GB of available disk space, with an operating system running windows 10
Visual Studio Code	Used in developing Mobile Application, it is on version 1.75.0
React Native	Latest version of React Native (0.77) using Expo SDK 52
Web Application	
Web Browser	An updated version of all modern browsers.
Visual Studio Code	1.6 GHz or faster processor, and 1 GB of RAM for optimal performance.
Node.js	64-bit processor and a minimum of 1 GB RAM required for installation and basic operation.
React and JSX (JavaScript XML)	At least 4GB of RAM and 10GB of storage space
MongoDB	At least 4 GB of RAM and 10 GB of free disk space, plus the space needed for data.

Table 2 shows the list of software used for web and mobile applications, and their respective system requirements.

Web browsers

The web application can be accessed with modern web browsers such as Edge, Firefox, Chrome, and Safari. However, using Internet Explorer requires additional measures to ensure compatibility with modern browser features.

Visual Studio Code

Visual Studio Code is used as the primary source-code editor for developing the application. With its support for various extensions and programming languages, it enhances the development process across different platforms. In this study, Visual Studio Code v1.99.3 is utilized for writing, managing, and maintaining both the server-side and client-side code.

Node.js

Node.js serves as the JavaScript runtime environment for building the server-side operations of the application developed in Visual Studio Code. For this study, Node.js version v22.11.0 is used to ensure full compatibility with the chosen libraries and frameworks.

React and JSX

React is used as the front-end library for building the user interface of the application. It enables the creation of dynamic and responsive web components that interact seamlessly with the server-side built in Node.js. React utilizes JSX, a syntax extension that allows writing HTML (Hypertext Markup Language) code directly within JavaScript files.

MongoDB

MongoDB is an open-source and NoSQL document database. It is used as the database management system that works alongside Node.js. It is responsible for storing, retrieving, and managing the application’s data in a flexible and scalable manner.

HARDWARE

Table 3. Hardware Specifications

Hardware	Specification
Personal Computer	In development, we used at least 8GB RAM and 256GB of free storage on the disk. The desktop runs on Windows 10 OS and uses a Ryzen 5 processor unit.
Android Smartphone	In development, we used at least 6GB RAM and ran on minimum Android OS version 11.0 ("Android 11") up to the latest Android version 14 .0 ("Android 14").
Arduino-powered Refreshable Braille Display (RBD) Device	This device utilizes the design created by Vijay Varada. It is assembled using the Arduino UNO R4 with Wi-Fi and Bluetooth compatibility, 3D printed parts and circuitry.

Table 3 shows the hardware specifications used for the development and testing of the proposed system.

Personal Computer

A desktop or laptop with 8GB RAM with available hard disk space of 256GB was used to develop the system. This specification is perfect for the development of mobile application and web system. The android studio requires 2GB RAM to use for testing mobile app and running emulators.

Android Smartphones

Smartphones running on at least Android OS versions of 11.0 ("Android 11") up to 14.0 ("Android 14") are the recommended system requirement to execute and to test smoothly the developed mobile application.

PEOPLEWARE

For the development of the Brailliant mobile application and web system, the following technical personnel are primarily involved:

System Developer

The person responsible for building the system according to the proposal. System developers are tasked with the crucial role of coding and creating a logical and efficient system. They are also mainly in charge in selecting the most compatible programming language especially for developing the mobile and web application as well as the hardware device.

System Analyst

The person responsible for analyzing user requirements and recommending the appropriate software and system architecture according to the proposed functions. The system analyst is mainly tasked to envision design, workflow, and the functionality ensuring that the system will be able to meet the aim of the project.

Mobile Designer

The person responsible for designing user-friendly yet modern mobile interfaces. The mobile designer should be able to recognize the user's knowledge and capabilities using mobile applications and utilize this to create a seamless user experience.

Web Designer

The person responsible for designing user-friendly and modern web interface the users. With the same tasks as the mobile designer, it is important that they recognize the user's knowledge and capabilities and tailor it to create a seamless user experience in the web platform.

Electronic Assembly Technician

The person responsible for the assembly and testing of the special hardware components of the Refreshable Braille display. The technician is primarily in charge of making sure that the device is integrated well and working properly with the mobile and web platforms.

Project Manager

The person responsible for overseeing the development of the project. They are tasked to make sure that all deliverables and system requirements are completed according the agreed schedule. Additionally, the project manager is in charge for coordinating the team's tasks and the needs of the team and the project are met.

Once the development of the system is completed, the users are expected to greatly benefit from Brailliant. The target users of the system are the following:

Mobile Users

Users are those teachers who will facilitate the learning of the students. Specifically, teachers who are not visually blind.

Web Users

Users are those teachers as well as IT faculty who will facilitate the learning of the students. Specifically, teachers who are not visually blind.

Brailliant Device Users

Users are those students who are visually impaired and will be guided by the teachers.

NETWORKS

The mobile application has features that require and does not require internet connection. The certain module or feature that requires internet connectivity is the ability to access the learning materials library in the database.

Wi-Fi (Wireless Fidelity) / Wired Connection

To run the mobile app faster and hassle-free, an internet speed of at least 5MBPS can help to access the learning materials available.

Mobile Data

To run the mobile app faster and hassle-free, at least 5MBPS is needed to access the learning materials available.

3.2 PROJECT TECHNICAL DESCRIPTION

SPECIAL HARDWARE

Brailliant Refreshable Braille Device (RBD)

Brailliant Refreshable Braille Device (RBD) is a device that is assembled using 3D printed materials. This device runs with Arduino R4 as its main processor. This will be the main device where the mobile application will be connected via wired/wireless connection. Each Braille module was made functional using electromagnetic cam actuators designed by Vijay Varada.

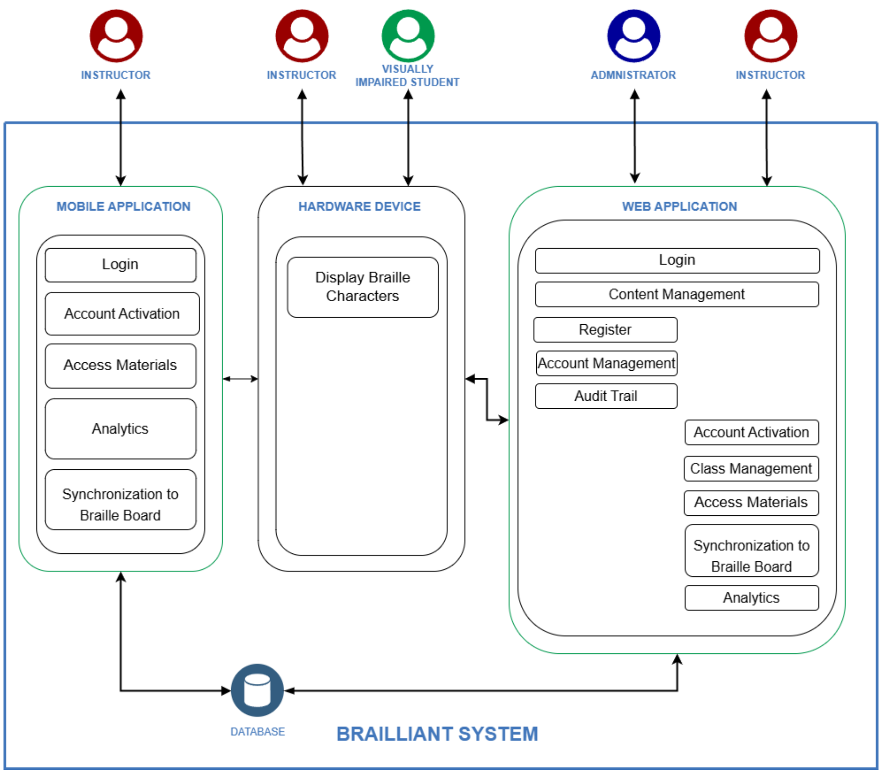

Figure 1. System Architecture

The Brailliant application has both online and offline features. This idea came up to respond to the availability of the connection of the person who is trying to access braille learning materials from the system. The features available in the application are discussed below.

Mobile Application Modules

Login Module

The login module allows the user to input their credentials to fully access the mobile application services.

Access Materials Module

The materials module provides the instructors with a list of available learning materials for them to use. In this module, the instructor can start and end one-on-one learning sessions with students. At the end of each session, instructors can assess the student’s performance, enabling the system to track student progress and instructional effectiveness over time.

Analytics Module

The analytics feature tracks and displays data on student activity, material usage, and system interactions, helping instructors and administrators monitor progress and improve learning strategies.

Synchronization to Braille Board

The instructors can connect the mobile application to the braille display. In this way, the application can translate any text into braille with the use of the braille display, allowing visually impaired students to access braille content in real-time.

Account Activation

To access advanced features such as analytics and other learning materials, users will have to activate their accounts through a One-Time Pin (OTP) sent through their emails. This verification step ensures that only authenticated and active users can access critical system functionalities.

Web Application Modules

Login Module

The login module allows the user to input their credentials to fully access the web application services.

Access Materials Module

The materials module provides the teachers with a list of available learning materials for them to use. In this module, the instructor can start and end one-on-one learning sessions with students. At the end of each session, instructors can assess the student's performance, enabling the system to track student progress and instructional effectiveness over time.

Analytics Module

The analytics feature tracks and displays data on student activity, material usage, and system interactions, helping instructors and administrators monitor progress and improve learning strategies.

Account Activation

To access advanced features such as class management, content management, analytics, and other learning materials, users will have to activate their accounts through a One-Time Pin (OTP) sent through their emails. This verification step ensures that only authenticated and active users can access critical system functionalities.

Synchronization to Braille Board

Just like in the mobile application, the instructors can connect the web application to the braille display. In this way, the application can translate any text into braille with the use of the braille display, allowing visually impaired students to access braille content in real-time.

Register Module

The register module registers the teachers to have the ability to access the application. The register module is only accessible in the web application using the administrator dashboard.

Content Management

Administrators and instructors can access the content management module. Instructors can upload materials that are subject to approval by the admin. The admin can also upload materials without the need for approval.

Audit Trail

This module allows the admin to track the activity of the users, whether it may be on the mobile application or the web application. This can only be accessed in the administrator's dashboard.

Account Management Module

The update account module updates the user's information in the system. This module is only accessible in the web application using the administrator dashboard.

Class Management Module

The class management module allows instructors to add, edit, and delete student lists in the system. This module enables instructors to track sessions and progress for each student.

Hardware Modules

Display Braille Characters Module

The display braille characters module enables the hardware device to show the text from the system to the users. This is shown through tactile Braille dots in the Refreshable Braille Display allowing a dynamic and interactive experience for the student and instructors.

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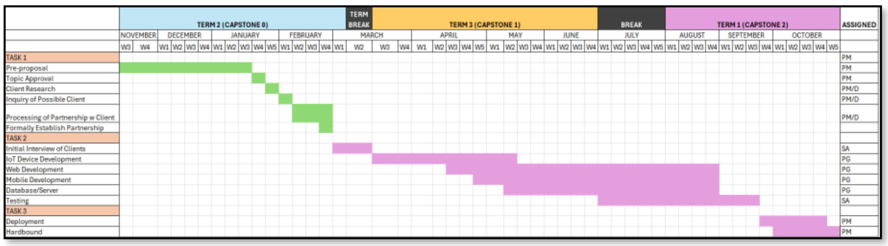
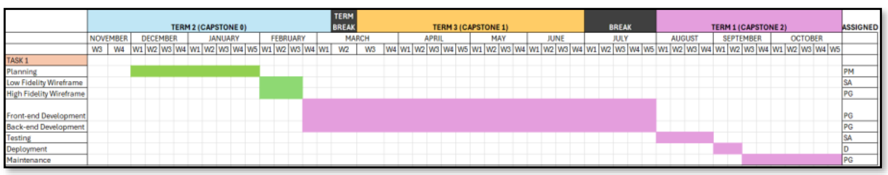
APPENDICES

GANTT CHARTS

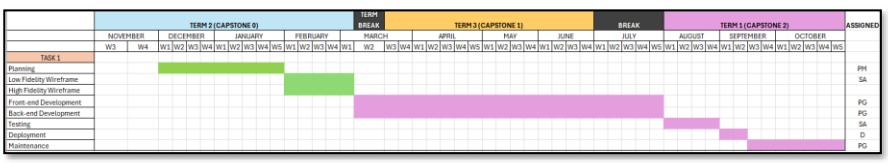
APPENDIX A. CASPTONE GANTT CHART



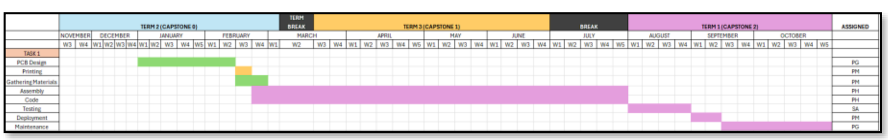
APPENDIX B. WEB DEVELOPMENT GANTT CHART



APPENDIX C. MOBILE DEVELOPMENT GANTT CHART



APPENDIX D. IOT DEVICE DEVELOPMENT GANTT CHART



Legend: Complete = Ongoing = Not Yet Started =

Project Manager = PM Documenter = D System Analyst = SA Programmer = PG

APPENDIX E. TOPIC APPROVAL FORM

NUMOA-SIT-0001

NU MOA
School of Information Technology
BS Information Technology

TITLE APPROVAL FORM

Team Name : Orbit

Proponents : MELO, Michael Joseph B. (with signature)
ROPETA, Aaron Jiro D.
VILLANUEVA, Ashley R.
VILLANUEVA, Ysabella Shery B.

Date/Time : January 20, 2024/ 8:00AM-9:00AM

Approved Proposed Title : Brailliant: A Web and Mobile-Based Refreshable Display Reading Board

Title Selection Committee	
Lorna C. Lim Faculty Expert	2-3-25 Sign here/Date
CHERYL ANN R. TINAPAN Faculty Expert	2/3/25 Sign here/Date
Emelyn A. Dovor Faculty Expert	2/4/25 Sign here/Date
MARILOU JAMIS Course Adviser	2/4/25 Sign here/Date
MARILOU JAMIS Dean	2/4/25 Sign here/Date

*** Sign only if the proposed title is **ACCEPTED** by the members of the committee.

APPENDIX F. LETTER OF INTENT

NU MOA
School of Information Technology
BS Information Technology

February 10, 2025

Mr. Patrick Nicole Ramos
Faculty, School of Information Technology
NU MOA

Dear Sir/Madam:

Greetings!

We, the third-year students from the School of Information Technology, are pursuing the Bachelor of Science in Information Technology with a specialization in Mobile and Web Applications and are currently doing system planning and development for our Capstone Project.

With the working title "**Brailliant: A Mobile and Web-based Refreshable Reading Display Board**," we are writing to respectfully ask for your approval in serving as our **CAPSTONE ADVISER** for the duration of the capstone project. We are extremely grateful that your skills, knowledge and expertise will be very beneficial and significantly enhance our project study.

Respectfully yours,

The Researchers | Orbit | INF225

Ysabella Shery B. Villanueva

Michael Joseph B. Melo

Aaron Jiro D. Ropeta

Ashley R. Villanueva

Conforme:

Mr. Patrick Nicole Ramos

APPENDIX G. PRE-PROPOSAL CAPSTONE FORM

NU MOA
School of Information Technology
BS Information Technology

PRE-PROPOSAL CAPSTONE TOPIC FORM

TEAM NAME	ORBIT	
	NAME OF THE PROPONENTS	**SIGNATURE**
Project Manager	**Villanueva, Ysabella Shery B.**	
Systems Analyst	**Villanueva, Ashley R.**	
Programmer	**Ropeta, Aaron Jiro D.**	
Documenter/Technical Writer	**Melo, Michael Joseph B.**	

TITLE OF PROPOSED CAPSTONE PROJECT *The title should briefly and simply reflect the main topic of the project.*	
Brailliant: Web and Mobile Based Refreshable Braille Display Reading Board	
CAPSTONE PROJECT THEME:	**Health and Wellness**
CHOOSE SPECIALIZATION:	☒ Mobile and Web Applications (MWA)
	☐ Multimedia Arts and Animation (MAA)
	☐ General Course
CAPSTONE PROJECT DISCIPLINE:	Mobile and Web Software Development

1. PROJECT CONTEXT
Please state the rationale of your proposed Capstone Project

Accessing information, education, and communication tools remains a significant challenge for visually impaired individuals, especially in the Philippines, where 1.98% of the population experiences visual impairment [1]. Visual impairment, as defined by the World Health Organization, occurs when an eye condition affects one or more functions of the visual system [2]. The International Statistical Classification of Diseases categorizes visual impairment into distance vision and near vision deficits. Individuals with visual impairments, particularly children, face additional challenges in cognitive, emotional, and physical development due to limited access to diverse information sources [4].

To mitigate these challenges, assistive technology devices (ATDs) have emerged as vital tools, aiming to enhance autonomy, independence, quality of life, and social inclusion. Among these, Refreshable Braille Displays (RBDs) are instrumental in providing visually impaired students with the ability to interact with digital content, thereby enhancing educational outcomes. Despite their benefits, current RBDs are often prohibitively expensive—ranging from \$3,500 to \$15,000—due largely to the use of costly piezo-electric actuators [6, 7].

Inspired by Vijay Varada's project—which demonstrated a cost-effective approach using an evaluation board and an inexpensive Braille module—this capstone project proposes the development of Brailliant. Brailliant is a novel system that will integrate an IoT device with a web and mobile based platform, aiming to deliver an affordable, portable, and innovative refreshable Braille display solution that is accessible to visually impaired students.

2. OBJECTIVES
State the general objective and at least 5 specific objectives of the study

This study aims to develop Brailliant, an integrated and cost-effective Refreshable Braille Display system that leverages IoT technology along with mobile and web platforms.

Page 1 of 4

- To create and prototype an affordable, portable RBD that integrates with mobile and web platforms, ensuring accessibility for visually impaired users through compatible software interfaces.
- To improve interaction of visually impaired students with digital educational content by providing a functional assistive device with real-time Braille display capabilities.
- To balance cost-effectiveness with robust functionality, ensuring Brailliant delivers accurate, efficient, and responsive Braille character refreshability using reliable, low-cost actuator technology.
- To ensure user-centric design and usability, by refining the functionality and overall user experience and gathering feedback from educators and visually impaired students.
- To address the financial burdens associated with high-cost refreshable Braille displays (RBDs) by offering a cost-effective alternative.

3. SIGNIFICANCE OF THE STUDY
Discuss the importance of the project once developed

Brailliant's potential to bridge the accessibility gap makes it a relevant and impactful project. By providing an affordable Braille display, the project can help visually impaired individuals achieve greater independence and educational opportunities. By integrating an IoT-enabled braille display with web and mobile platforms, Brailliant enhances access to digital content, promoting independent learning.

For **visually impaired students**, this study provides an opportunity to interact with digital educational materials more efficiently, fostering greater engagement in academic activities.

For **educators** benefit from an interactive platform that allows them to support students with real-time text-to-braille translation and progress tracking.

For **educational institutions** gain access to a cost-effective solution that expands learning opportunities without the financial burden of expensive assistive devices.

4. SCOPE AND DELIMITATION
Refers to the scope and inclusive frame/s of references as well as delimitation/s of the study

This study focuses on the design and development of Brailliant, a web and mobile system integrated with an IoT device. The project aims to enhance the learning experience and accessibility with digital educational content of visually impaired students. The system took inspiration from Vijay Varada's project, utilizing evaluation board and the inexpensive components for the braille module to achieve reliable functionality and cost-efficiency of the device. It features text-to-braille conversion, interactive user interfaces, and data synchronization between the IoT device and digital platforms, and monitoring learning progress through integrated analytics, ensuring that Brailliant functions as a collaborative educational tool to complement traditional teaching methods.

However, this study is delimited to educational applications and restricted to instructors, system administrators, and visually impaired students as its primary users. It is not intended for full-scale production or commercialization, as it is restricted to the development and design of a functional prototype that prioritizes affordability and functionality. Thus, the incorporation of advanced features is limited compared to those found in premium refreshable braille displays.

5. RELATED STUDIES

Present at most 5 studies to support your rationale and problems identified by the current systems. Note: Find the notable and published studies (either Scopus or ISI indexed papers)
The literature on refreshable Braille display technologies provides a strong foundation for this project. Leonardis et al. [8] surveyed emerging RBD technologies, highlighting advancements that reduce costs and improve accessibility—an approach that aligns with Brailliant IoT's goal of enhancing user experience through affordable solutions. Russomanno et al. [9] emphasized the importance of tactile feedback, showing that devices lacking sufficient tactile cues result in increased reading errors, thereby underscoring the need for multi-cell displays. Bettelani et al. [10] introduced the Readable system, a single-cell electromagnetic RBD, which, despite its cost-effectiveness, faced challenges in user experience and design complexity. These studies reinforce the need for innovations that balance affordability with usability. Additionally, Kim et al. [11] demonstrated the feasibility of using a flip-latch electromagnetic actuator in a portable RBD, offering insights into achieving low power consumption and compact design—features that are central to Brailliant.

5. PROJECT DESIGN / DEVELOPMENT PLAN

Brailliant is a web and mobile based refreshable display system that integrates IoT technology for wireless connectivity. The system provides a device and system platform for visually impaired students to learn and engage with digital educational content in braille format. This innovation addresses the accessibility gap and provides cost-efficient refreshable braille display.

Brailliant serves as an extension of Vijay Varada's project of developing electromechanical refreshable braille module. In his award-winning project, he employs electromechanical system to operate the mechanism of small pins to generate patters represented as pins [12]. With the help of evaluation board and programming, each module can generate the preferred braille pattern.

To further enhance Vijay's work, the researchers established a web and mobile platform that revolves around the refreshable braille display model to fully optimize and enhance the functionality of the device for performance and efficiency. This integration allows resourceful functionalities between the device and system that provides digital interaction between visually impaired students and instructors.

Brailliant features a real-time text-to-braille translation, with the platform visualizing the braille output presented in the device and the character it represents. The system also features integrated analytics to monitor the progress and performance of the students.

The researchers will use React Native for developing the proposed system. As for the hardware specification, 3d printing will be used for the braille module and customized printing for PCB and evaluation board. The needed components for creating the braille module are ferrite core, 0.05mm copper wire, pitch pin headers, neodymium magnets, and PCB.

6. REFERENCES

Use IEEE citation and referencing style

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SUBMITTED BY:	CHECKED BY:
Project Manager (Signature over Printed Name) Date: ______________	Course Instructor (Signature over Printed Name) Date: ______________
NOTED BY: OIC-Dean, School of Information Technology (Signature over Printed Name) Date: ______________	

DIAGRAMS

APPENDIX H. SYSTEM ARCHITECTURE

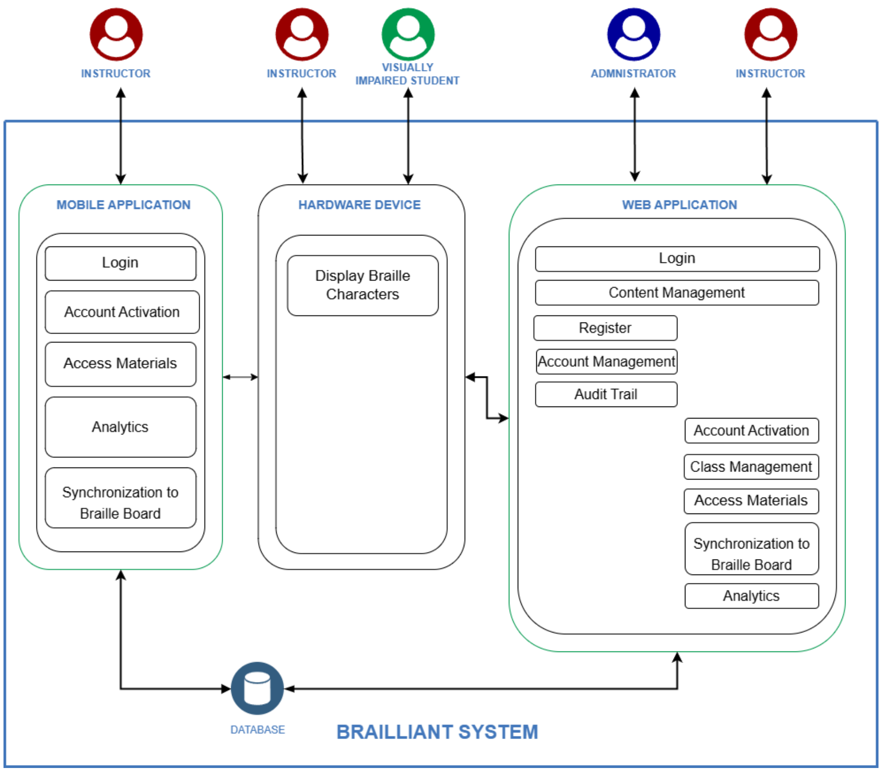

Figure 2. 3-Tier System Architecture

The illustration represents the system architecture diagram of Brailliant, which contains the system components along with their respective relationships and interactions the users. The provided system architecture is functional for both mobile and web browsers.

The diagram is composed of three users: Visually impaired students, instructors, and system administrator, each having own part in the system.

The visually impaired students mostly read the braille content provided by the system.

In the web application, the administrator mainly operates the user management system, providing and making changes in user accounts of the instructors.

Furthermore, the instructors serve as the primary users of the system. They engage in most functionalities of the web and mobile applications. They can upload materials in the system to provide content to the students. The instructors can also access the analytics to have information on the students' performance after reading the braille content. And lastly, the instructors are responsible for synchronizing the school materials from the application to the braille display for the students to read.

In addition, the database, where all the system data is stored and managed, contains the essential data for the system to function.

APPENDIX I. MOBILE USE-CASE DIAGRAM

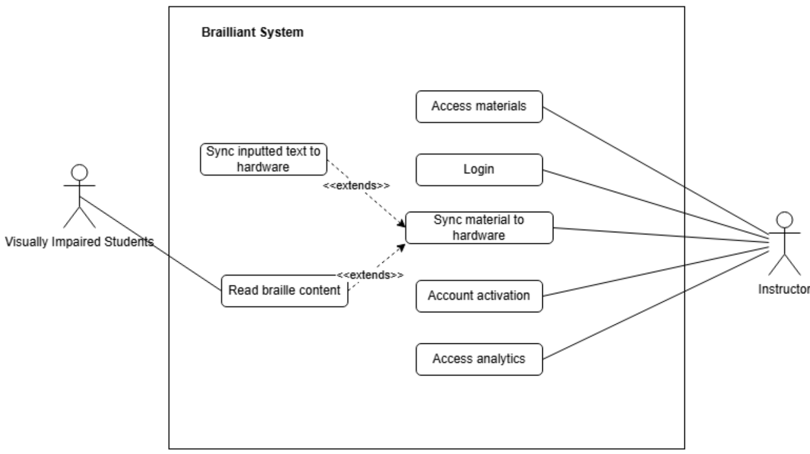

Figure 3. Mobile Use-Case Diagram

The illustration portrays how the Brailliant mobile system interacts with its users and the relationships of the use cases to each other. The diagram comprises instructors and visually impaired students, with each responsibility and interaction within the system.

Instructors serve as the primary users of the system. The instructors can activate their accounts to access advanced features in the system. Inactivated accounts can only access text customization and braille materials for grades 1 and 2. In contrast, activated accounts have full access to all features within the system. In addition, some of the functionalities the instructors can access are signing in, accessing analytics, accessing materials, and synchronizing learning materials to the Braille display hardware. Also, they are responsible for synchronizing learning materials from the mobile application to the Braille display, with the option to input their own text.

Furthermore, the visually impaired students mainly interact with the Braille display to engage with course materials.

APPENDIX J. WEB USE-CASE DIAGRAM

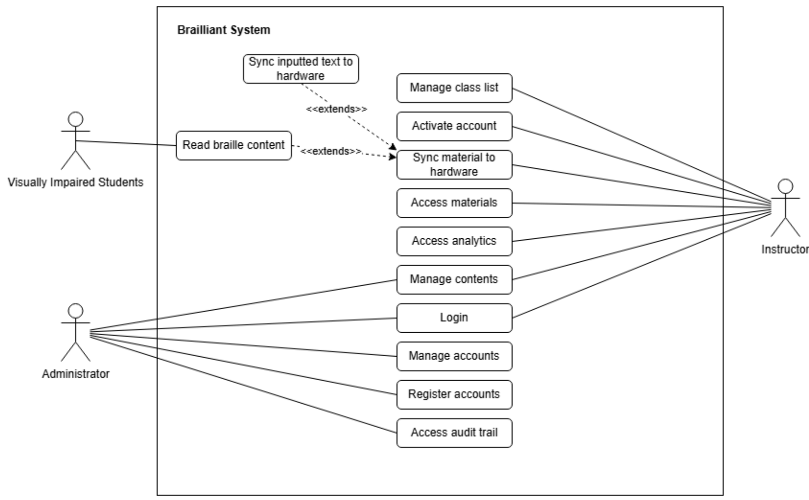

Figure 4. Web Use-Case Diagram

The illustration portrays how the Brailliant web system interacts with its users and the relationships of the use cases to each other. It includes the system administrators, instructors, and visually impaired students, with each responsibility and interaction within the system.

The system administrators are responsible for supervising the overall functionality of the system. They provide and manage user accounts for the instructors so that they can have access to the system. With regard to the school curriculum, the system administrators can upload and manage the necessary learning materials that correspond to the student's academic needs. The administrator can also access the audit trail to review all actions taken within the system.

Moreover, the instructors serve as the primary users of the system. Similar to the system administrators, the instructors can manage learning content such as updating, organizing, and uploading additional learning materials, which are subject to approval by the admin. With class list management, instructors can view, add, edit, and delete students from the class list. The instructors can also activate their accounts to access advanced features in the system. Inactivated accounts can only access text customization and braille materials for grades 1 and 2. In contrast, activated accounts have full access to all features within the system.

In addition, some of the functionalities the instructors can access are analytics, access to materials, and synchronizing learning materials to the Braille display hardware. The instructors are responsible for syncing learning materials from the web to the Braille display, with the option to input their own text.

Lastly, the visually impaired students mainly interact with Braille display to engage with course materials.

LETTERS AND TRANSCRIPT OF INTERVIEWS

APPENDIX K. REQUEST LETTER FOR RESEARCH

SDO PASAY CITY
Records Section
RECEIVED
Date & Time: 1 0 FEB 2025
By: MHHPNK 4:46
Tracking No.: REC-0031-0047

NU MOA
School of Information Technology
BS Information Technology

February 10, 2025

Joel T. Torrecampo
Schools Division Superintendent
Office of the Schools Division
Superintendent

Dear Mr. Joel Torrecampo,

We hope this letter finds you in good health and high spirits! We, the undersigned, are students from National University MoA, currently conducting our capstone project titled "Brailliant: Web and Mobile-Based Refreshable Braille Display Reading Board" as part of our academic requirements. Our research aims to develop a cost-effective refreshable Braille display to improve accessibility for students with visual impairments, enabling real-time interaction with digital content. By reducing financial barriers, it seeks to promote inclusive education and digital literacy.

In this regard, we would like to request your permission to conduct our study in Philippine National School for the Blind (PNSB) under the Schools Division Office of Pasay City. Our research will involve students and instructors, and will strictly adhere to ethical research guidelines, ensuring confidentiality, voluntary participation, and compliance with DepEd policies.

We are more than willing to provide any necessary documents and comply with any additional requirements to facilitate this request. We assure you that all data collected will be used solely for academic purposes.

Provided below is our **statement of the problem** to give further insight on our study:

- The existing refreshable Braille display technology is expensive, limiting its adoption in educational institutions.
- Refreshable Braille displays enable independent digital reading and navigation but remain costly and inaccessible to many.
- Limited access to affordable Braille technology prevents many visually impaired students from fully engaging with digital learning materials.
- Expensive refreshable Braille display limits accessibility, hinders literacy development, and limits educational opportunities for many visually impaired individuals.

As part of our research, we intend to ask questions such as:

- What does the current Braille curriculum include, and how is it structured?
- What are the current methods used in teaching Braille to students?
- How do students at your school primarily access Braille materials?
- Have you or your students used a refreshable Braille display before? If so, which model(s)?

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- How frequently do students and instructors have access to Refreshable Braille Displays (RBDs)?
- What challenges have you encountered in teaching Braille with and without the use of RBDs?
- Are there any features in current refreshable Braille displays that students find particularly helpful?
- In your opinion, how much impact would an affordable Refreshable Braille Display have on Braille literacy and accessibility for visually impaired students?
- Are you interested in integrating RBDs in your method of teaching?
- What features do you think it'll be helpful to you if you are to develop a system that integrates an RBD?
- With the help of assistive devices such as RBDs, what would you like to improve in the current mode of Braille instruction?

We sincerely hope for your favorable consideration of our request. Should you require further details, please feel free to contact us through text, **09556338287** or via email ysabellashery@gmail.com. We would greatly appreciate your endorsement in facilitating this academic endeavor.

Thank you for your time and support. We look forward to your positive response.

Sincerely,

Ysabella Shery Villanueva
3rd Year Student, BSIT-MWA

Aaron Jifo Ropeta
3rd Year Student, BSIT-MWA

Michael Joseph Melo
3rd Year Student, BSIT-MWA

Ashley Villanueva
3rd Year Student, BSIT-MWA

Approved By:

Marilou N. Jamis
Dean, School of Information Technology
Date: February 10, 2025

APPENDIX L. ENDORSEMENT LETTER

Republic of the Philippines
Department of Education
NATIONAL CAPITAL REGION
SCHOOLS DIVISION OF PASAY CITY

Office of the Schools Division Superintendent

1st Indorsement
February 25, 2025

Respectfully referred to **MS. NORA S. PABLO,** School Principal I, Philippine National School for the Blind, the attached letter-request of **Ms. Ysabella Shery Villanueva,** researcher, N.U. School of Information Technology (MOA) , with the information that this Office interposes no objection to conduct a study with selected learners and school personnel at the aforementioned school. The school schedule of which shall be determined by the School Principal concerned to complete the required information needed, on conditions that:

- no school/office materials shall be used for the purpose; and
- conduct of research activity shall not interfere with the normal day-to-day operations of the school

In this regard, please be guided of **DepEd Order No. 16 s. 2017 – Research Management Guidelines** with regards to the implementation, facilitation and ethical standards to be observed during the conduct of any research undertakings as prescribed by the Department.

Likewise, this Office be furnished a copy of the research findings/output after the completion of the study.

JOEL T. TORRECAMPO, CESO VI
Schools Division Superintendent

MJDB/smoc/SGOD Research- Ms. Ysabella Shery Villanueva
003-I027/February 25, 2025

Address: P. Zamora St., Pasay City
Telephone Numbers: 831-6660 831-7948 831-7933
E-mail Address: depedpasaycity@yahoo.com/deped.pasay@deped.gov.ph

HIGH FIDELITY WIREFRAMES

APPENDIX M. MOBILE WIREFRAMES

Figure 5. Mobile Landing Page

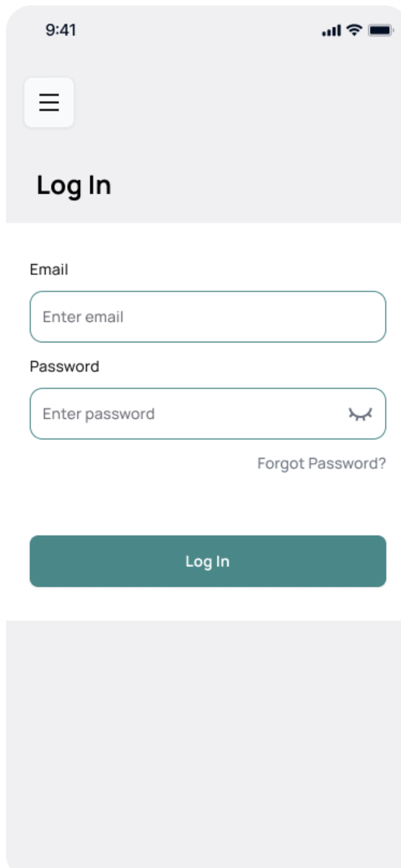
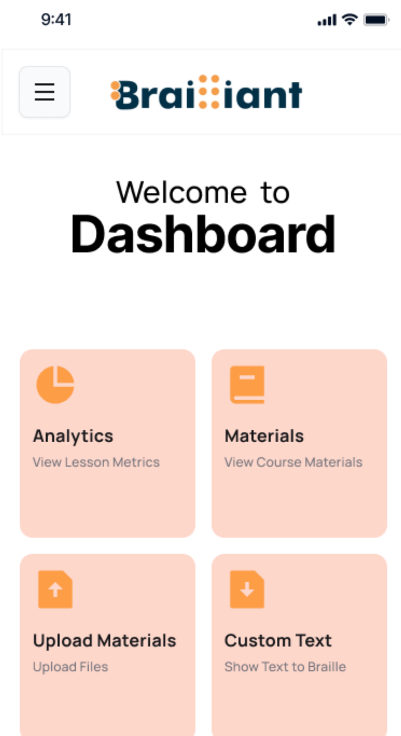


Figure 6: Mobile Login Page



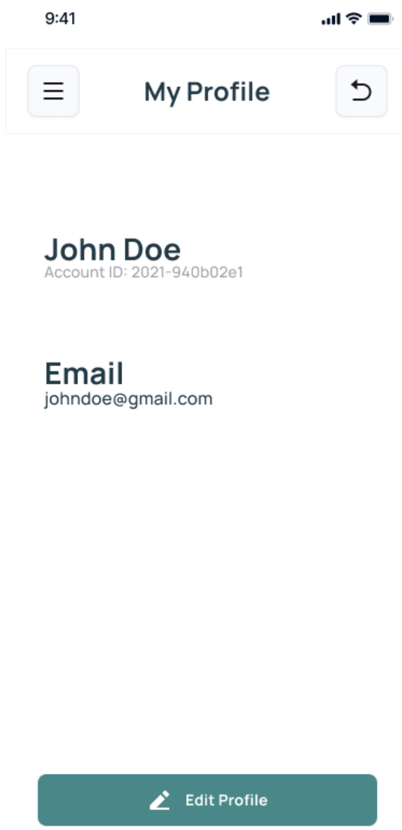
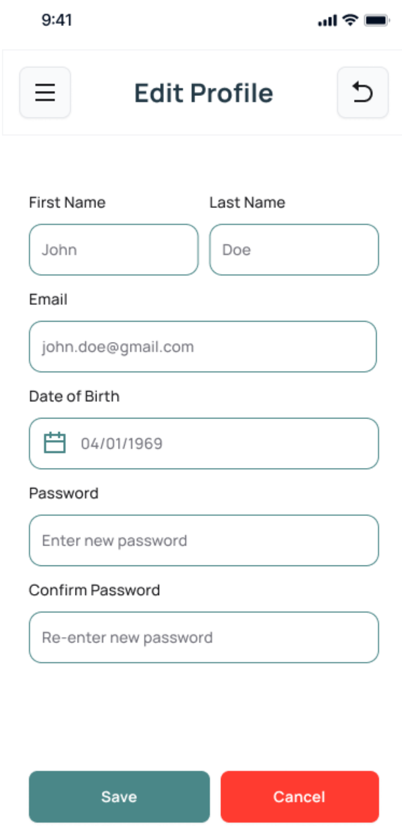


Figure 7: Mobile Dashboard Page **Figure 8: Mobile Profile Page**



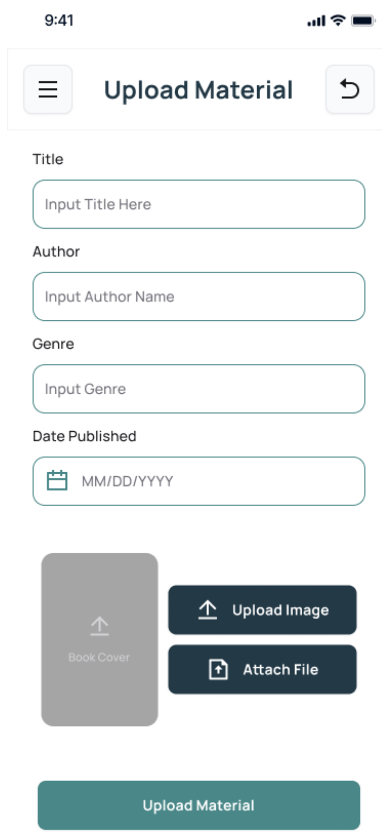


Figure 9: Mobile Edit Profile Page

Figure 10: Mobile Upload Material Page

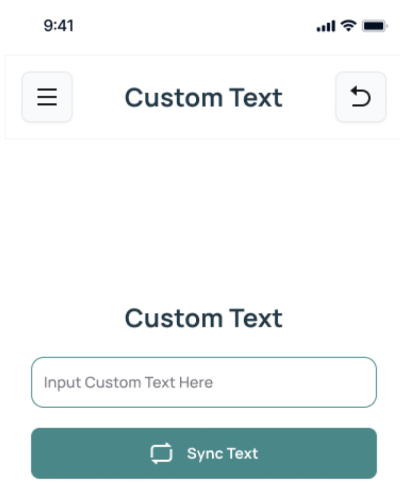


Figure 11: Mobile Custom Text Page

Figure 12: Mobile Materials Page

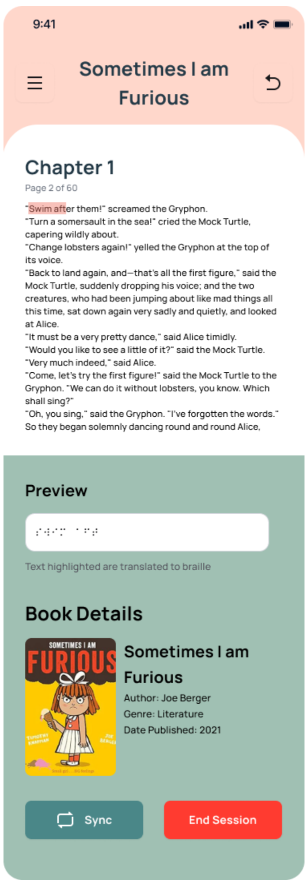


Figure 14: Mobile Book Details Page

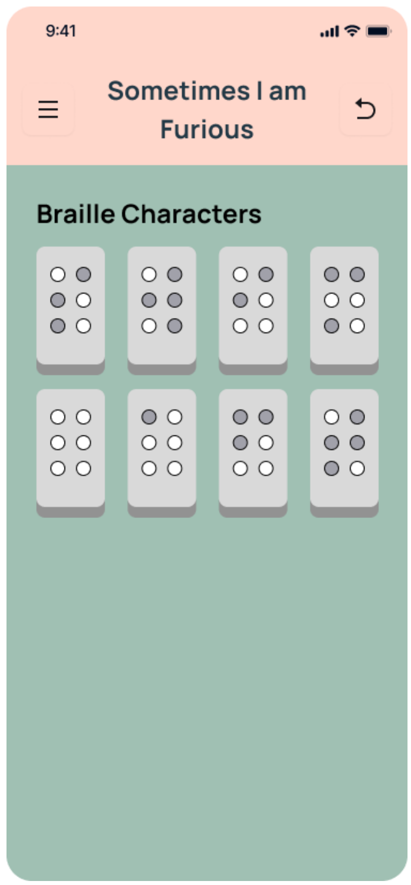


Figure 13. Mobile Braille Material Characters Page

APPENDIX N. WEB WIREFRAMES

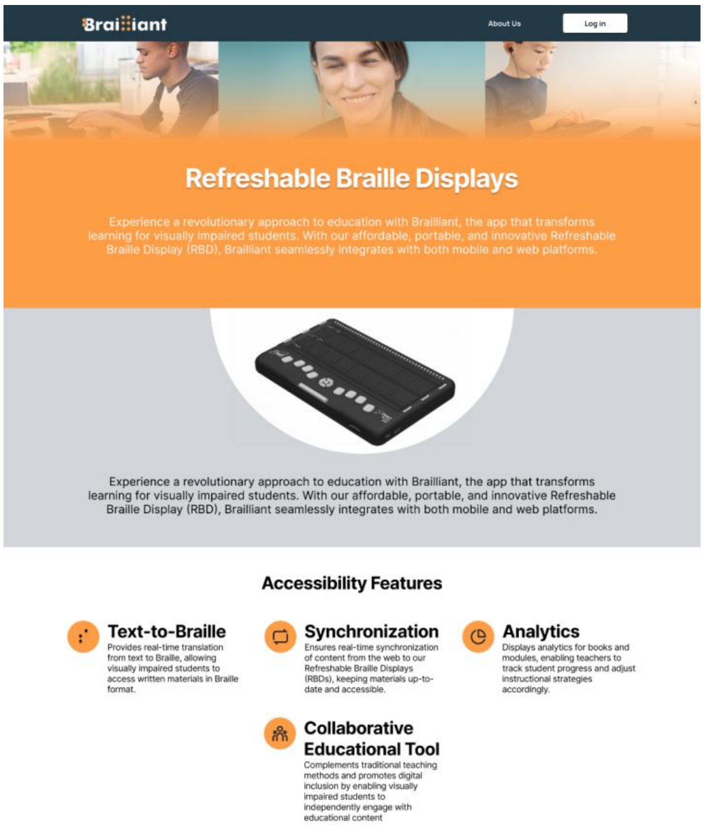


Figure 15: Website Landing Page

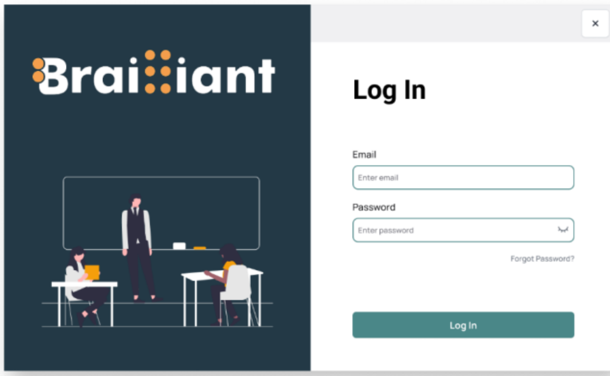


Figure 16: Website Login Modal

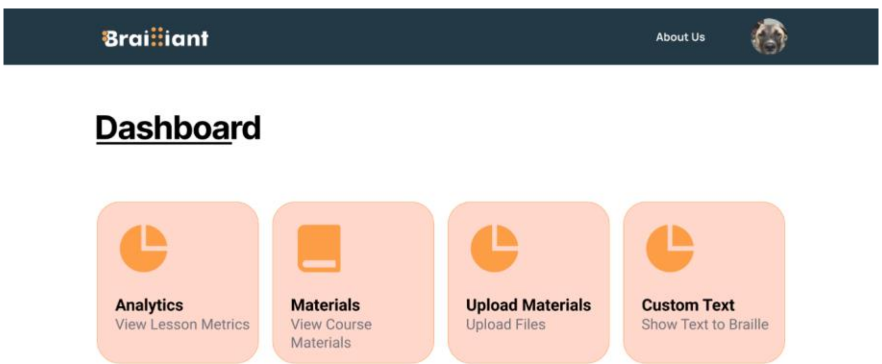


Figure 17: Website User Dashboard Page

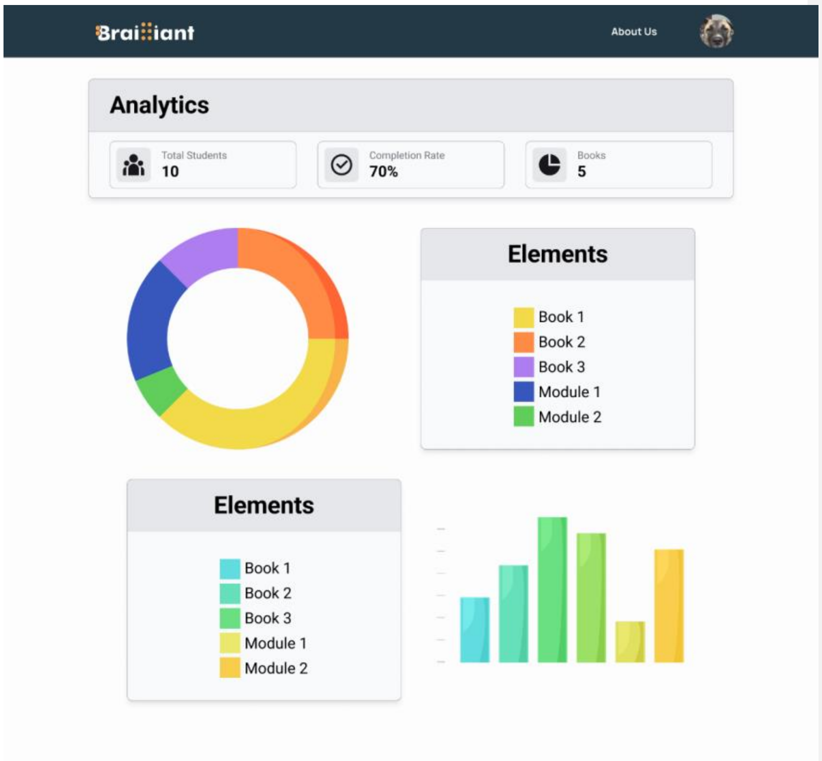


Figure 18: Website User Analytics Page

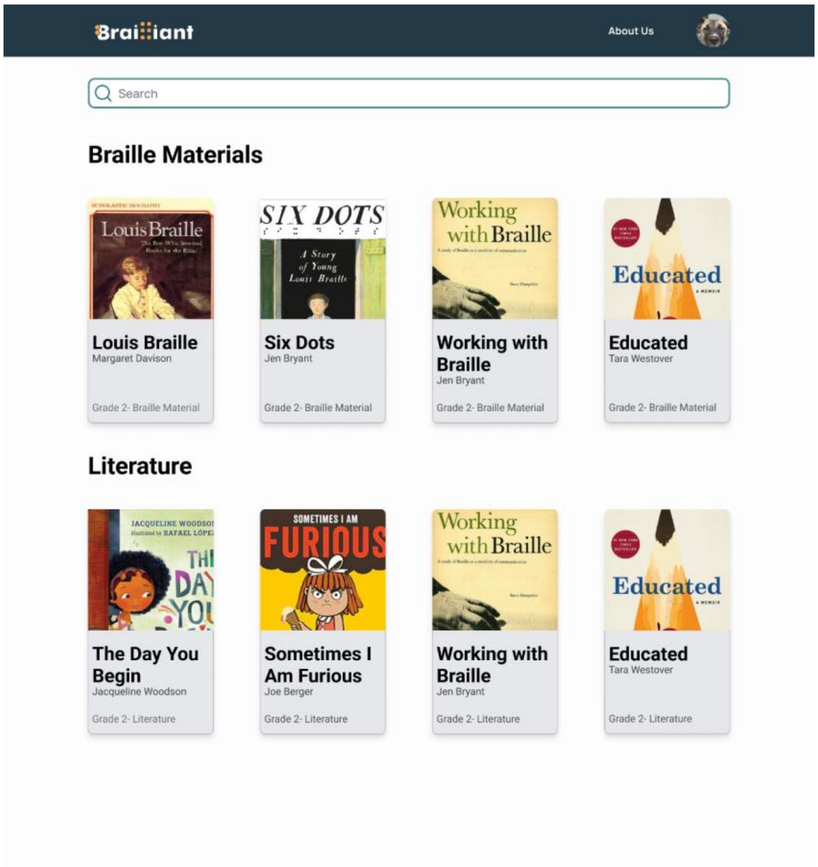


Figure 19: Website User Materials Page

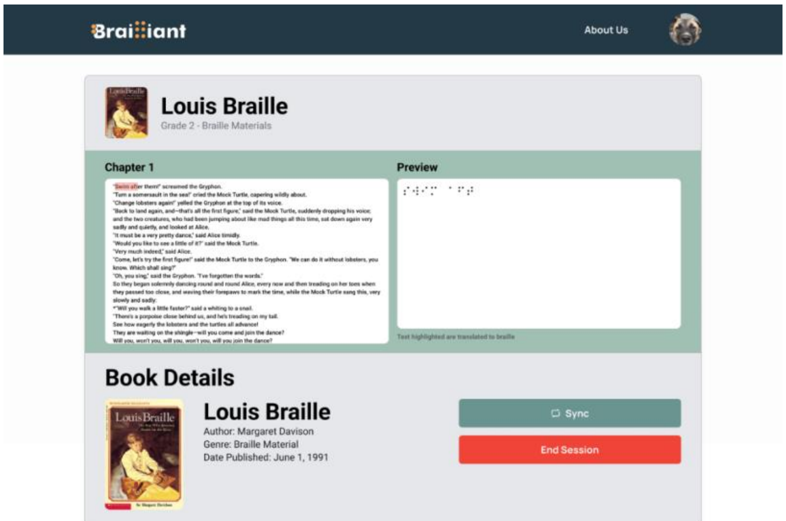


Figure 20: Website User Book Details Page

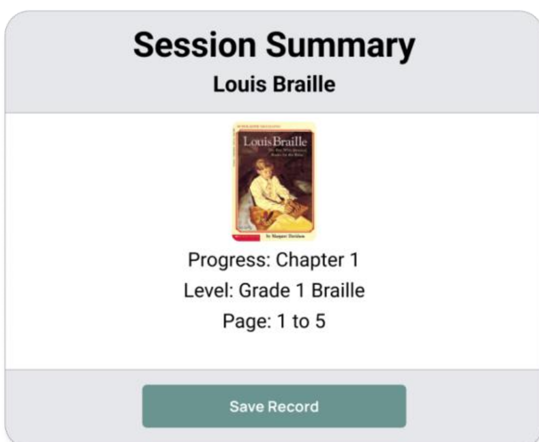


Figure 21: Website User End Session Modal

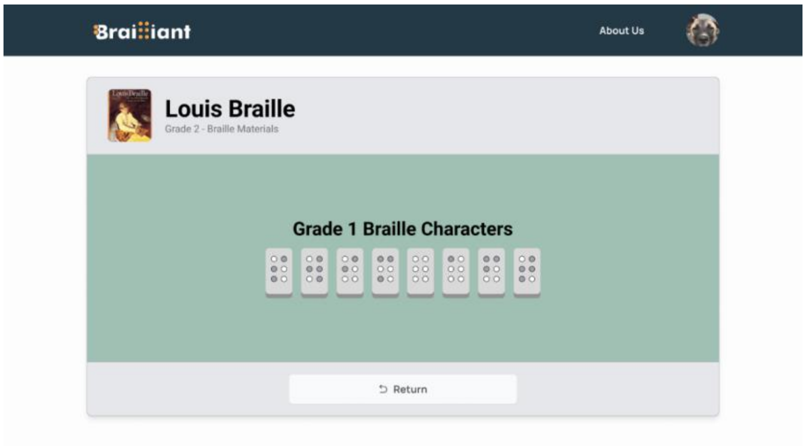


Figure 22: Website User Braille Materials Character Page

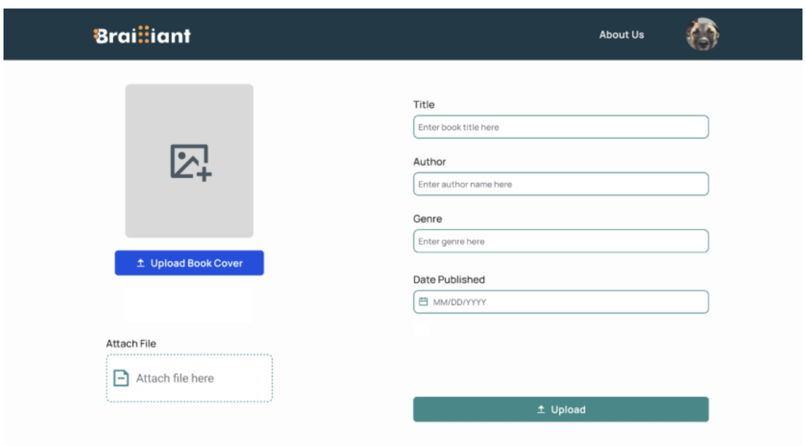


Figure 23: Website User Upload Materials Page

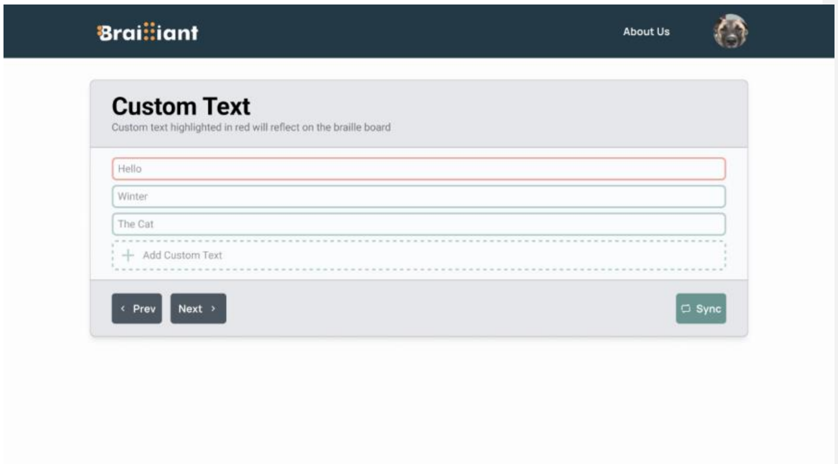


Figure 24: Website User Custom Text Page

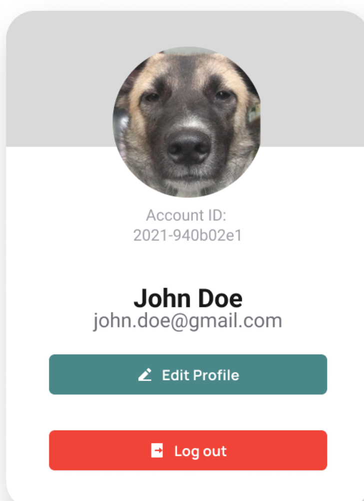


Figure 25: Website User Profile Modal

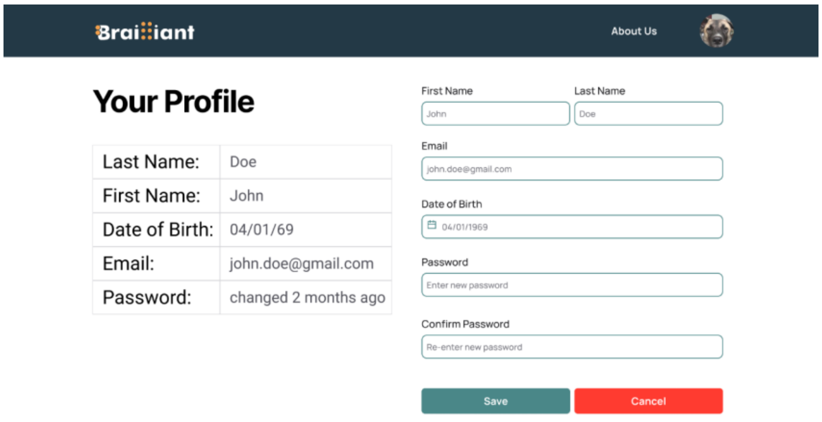


Figure 26: Website User Edit Profile Page

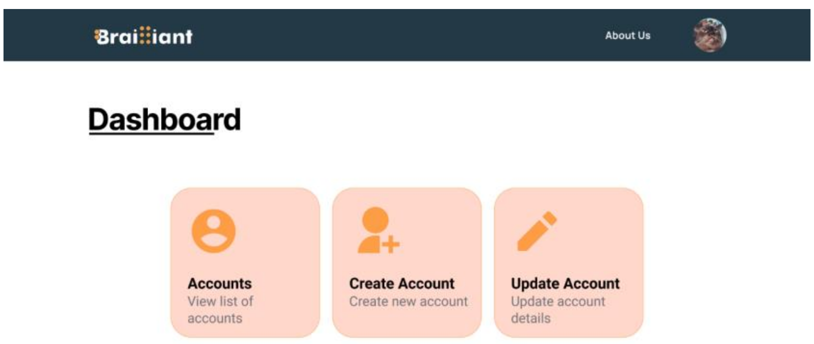


Figure 27: Website Admin Dashboard Page

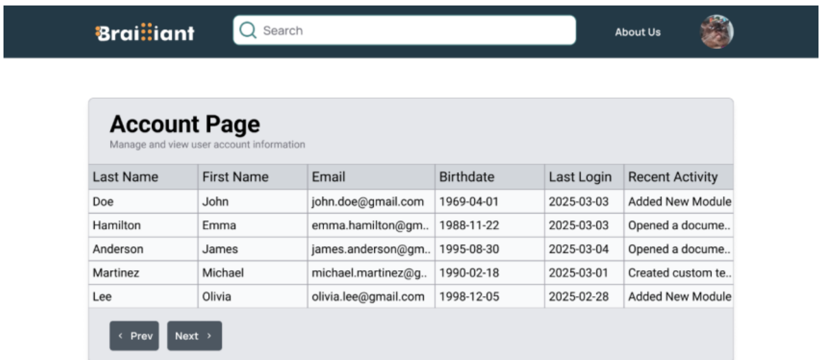


Figure 28: Website Admin Account Page

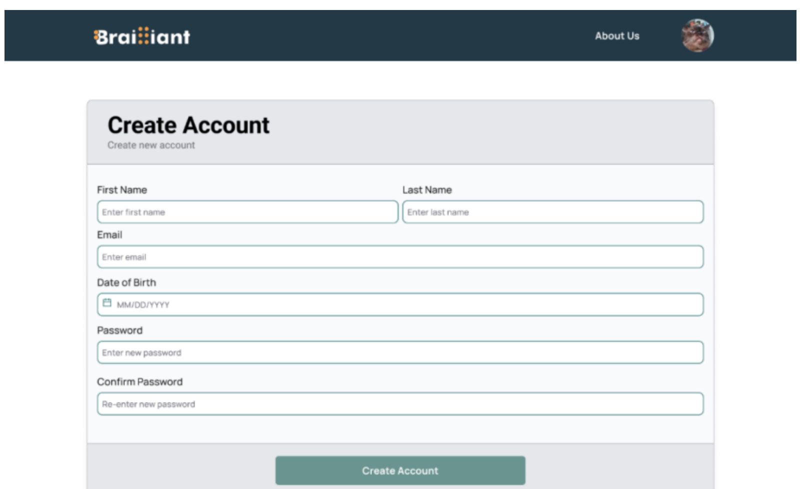


Figure 29: Website Admin Create Account Page

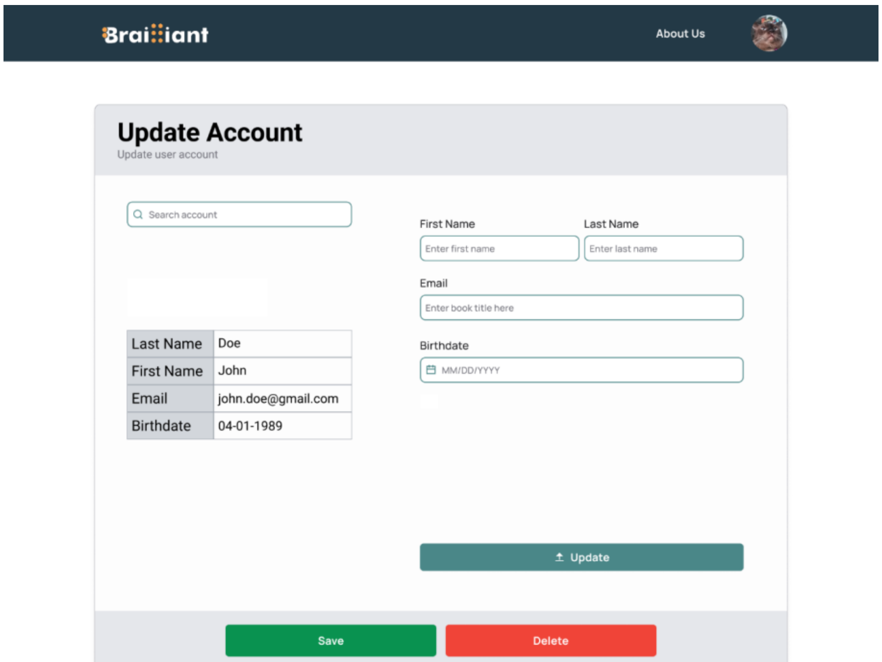


Figure 30: Website Admin Update Account Page

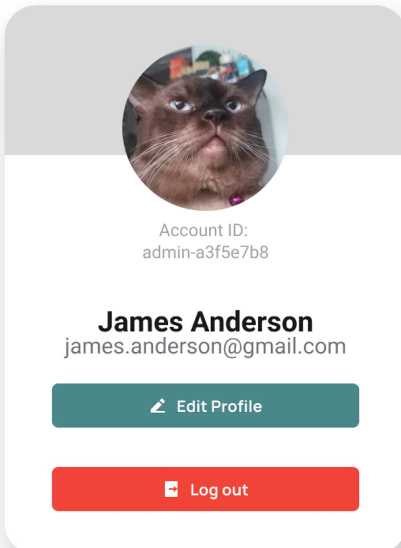


Figure 31: Website Admin Profile Modal

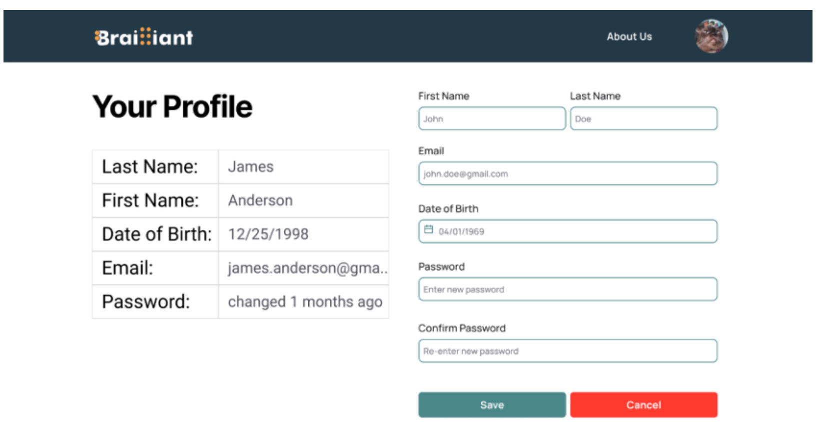


Figure 32: Website Admin Edit Profile Page