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I-Attend: A Smart Attendance System for Secondary Schools Using RFID

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ABSTRACT

I-Attend is a smart attendance system targeted at secondary school administrators and teachers. The purpose of this project is to develop a smart attendance system integrated with RFID technology to improve the efficiency and accuracy of attendance tracking. The research problems investigated include the challenges associated with the traditional method of attendance systems, such as time consumption, proneness to error, and difficulties in data retrieval due to the size of the student population. The study seeks to address these issues by proposing a technological solution that enhances the attendance process for administrators and teachers. This project design involves the development of a web-based attendance tracking system that utilises RFID technology and cloud computing. The I-Attend employs functionality testing and usability testing, revealing a mean score of 4.57, indicating a high level of satisfaction, and achieving a score of 4.71 for its ease of use. To conclude, the I-Attend effectively addresses the limitations of traditional attendance tracking methods. The positive feedback and high satisfaction from users show that the system not only meets the specific needs of administrators and teachers but also enhances the efficiency of overall attendance management in secondary schools.

1. INTRODUCTION

Attendance systems have been in place since the 1800s in a variety of fields, including the education sector. Over time, the attendance system has changed from manual to automatic. In the Malaysian education sector, attendance is mandatory for every school. Typically, paper records are used when taking attendance, and students will respond when teachers call out their names. The manual attendance method is plagued by several disadvantages, such as its time-consuming nature, susceptibility to errors, and difficulty in retrieving data, especially when dealing with a high number of students (Qureshi, 2020).

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With the advancement of technology, numerous mechanisms for recording student attendance have been developed, including the use of fingerprints and face recognition (Abdul Rahman, 2019; Sekolahmalaysia.com, 2016). However, every approach has its individual constraints. More precisely, the fingerprint detection approach encounters difficulties in recognising the fingerprints of both students and teachers, while the face detection method exhibits reduced accuracy as a result of uncooperative factors (Abdul Rahman, 2019; Wang & Li, 2022). In order to resolve this problem, it is imperative that the existing attendance systems are updated to integrate RFID technology, which is presently not being implemented by any schools. RFID has several advantages, including automated student attendance recording, time-saving capabilities, and preventing lost student attendance records (Shah & Abuzneid, 2019; Tan et al., 2018).

The I-Attend project has three main objectives: to identify user requirements to meet the specific needs of administrators and teachers in the development of a smart attendance system; to develop a smart attendance system for secondary schools using RFID technology; and to evaluate the functionality and usability of the I-Attend Web Application System. The scope of this project is the development of the I-Attend smart attendance system, focusing on secondary schools to enhance attendance tracking through RFID technology. It includes the design, implementation, and testing phases, ensuring the system meets functional and non-functional requirements while addressing user needs. In addition, the scope encompasses user training, system documentation, and future recommendations for improvements, aiming to create a comprehensive solution for efficient attendance management. In order to achieve a smart school purpose, I-Attend would be developed using Visual Studio Code and Firebase to store student attendance records, while the hardware needed to build this project includes the RFID MFRC522, ESP32, and LCD Display.

2. LITERATURE

The development of the I-Attend project entails utilising web-based applications and architecture, which have become increasingly widespread in various sectors, including education. A web-based application runs on any platform that has a web browser and internet connection, making it accessible and versatile (Angelica, 2023). The architecture of such applications, typically implementing a 3-tier structure, includes the presentation layer for the user interface, the application layer for processing user input and data manipulation, and the data layer for storage and retrieval (Jagoda, 2023).

In the context of I-Attend, choosing the appropriate architecture is crucial to ensure the system meets the project's requirements, provides reliable user experiences, and is scalable and future-proof. Among the different architectures, Single Page Application (SPA) has been chosen. SPA is combined with a web-based database management system. As an SPA, it provides a seamless user experience by dynamically updating content within a single web page, reducing the need for full page reloads (Dhaduk, 2021). This design choice enhances the speed and responsiveness of the application, which is crucial for tasks such as marking attendance or viewing student records. Compared to traditional methods, web-based applications are cheaper and quicker to develop because they require less time and effort to link a URL to an application (iTrobes, 2023). Besides that, they can be accessed on any device with a web browser and internet connection, enhancing flexibility and productivity for users (Khamooshi, 2019). Moreover, web-based applications can be easily scaled and modified to meet user demands, and they are typically hosted on dedicated servers, improving security and breach detection (LinkedIn, 2023; Muhammad Rehan, 2023).

In terms of storing data, I-Attend implements cloud computing, which is beneficial on its own, such as cost savings, more collaboration, faster time to market, scalability, and flexibility (IBM, 2023). In this age of rapidly advancing technology, cloud computing offers a variety of services to satisfy the requirements of a web application system. There are four types of cloud computing service models, which are software as a service, platform as a service, infrastructure as a service, and blockchain as a service

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(Huawei, 2023). I-Attend uses Blockchain as a Service (BaaS) cloud computing, specifically leveraging Firebase as its backend platform. Firebase provides various services such as real-time databases, authentication, and hosting, allowing I-Attend to focus on developing the application's features without managing the underlying infrastructure (Huawei, 2023). Therefore, the BaaS is an ideal cloud computing model for creating a smart attendance system like I-Attend.

For web-based development, programming languages such as HTML and JavaScript have been chosen to develop the I-Attend Web Applications. HTML provides the structural foundation, and JavaScript allows for interactive and complex features for building an interactive web application. Meanwhile, the development of the I-Attend necessitates the integration of both hardware and software tools, such as sensors and microcontrollers, a process known as device development. The chosen sensor for I-Attend is the MFRC522 RFID module, which can identify objects up to 5 cm range (Einstronic, 2021). In the I-Attend project, the ESP32 serves as the key controller. Compared to the other microcontrollers, ESP32 is more suitable for attendance tracking projects, and it is more powerful than ESP8266 in terms of processing power, memory capacity, and GPIO (JAK Electronics, 2024).

3. METHODOLOGY

The methodology chosen for the I-Attend project helps keep track of the time frame to complete the development of the web-based application and device. This project chooses an Agile SDLC technique that includes five phases, which are requirements analysis, design, development, testing, and documentation, as shown in Fig. 1. Agile SDLC is a popular software development methodology that focuses on a non-linear, fast-adapting process, ensuring speedy, high-quality result delivery. The benefits of Agile include improved project management, reduced risks, enhanced customer satisfaction, and high-quality products (Ta, 2020). Besides that, Agile is the recommended development methodology for IoT projects with short lead times and increased productivity because it facilitates continuous software delivery and streamlines the software delivery process (3Point3 Labs, 2024). As a result, Agile is suitable for this project, which requires a lot of testing and quick adjustments throughout the project lifecycle.

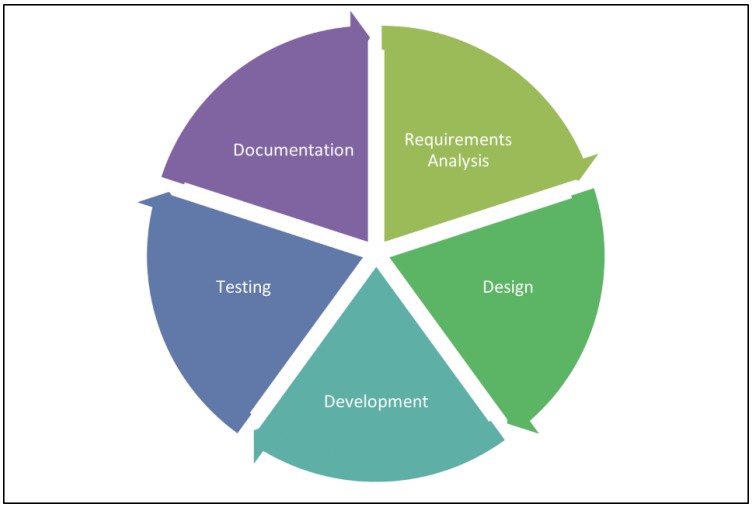

Fig. 1. Agile Methodology

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3.1 The Development of a Smart Atttendance System for Secondary Schools using RFID

The first phase to develop I-Attend is requirement analysis. In this phase, research is conducted to ascertain the project objectives, problem, scope, user requirements, and relevant technologies of the study. This project focused on IoT technology and school attendance to help schools manage their attendance system smartly and efficiently. The functional requirements for the I-Attend include user registration and login, an administrator dashboard for managing student attendance and information, a teacher dashboard to monitor student attendance and student information, and user support for system assistance. The non-functional requirements emphasize usability to ensure the I-Attend is user-friendly with a minimalist and consistent interface for easy access by administrators and teachers. During this phase, the first objective, which was to identify user requirements for meeting the specific needs of administrators and teachers in the development of a smart attendance system, has been successfully achieved.

The design phase is the second step in I-Attend's development. This phase is a blueprint for the project to show the interface between the system and hardware. The use of tools such as draw.io, Balsamiq, and circuito.io helps in demonstrating the database design, system prototype, and hardware diagram as shown in Fig. 2, 3, and 4 respectively.

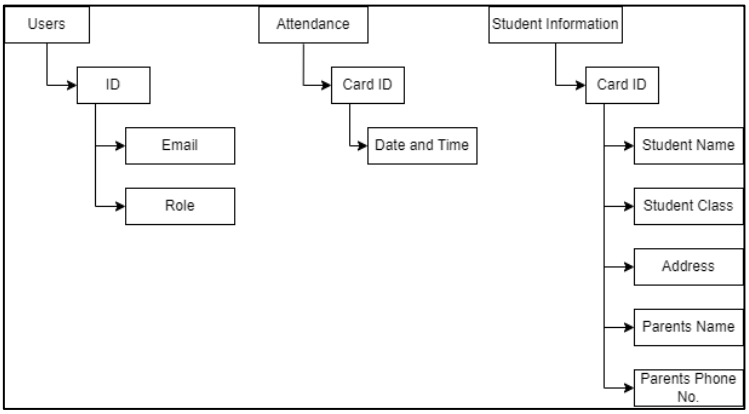

Fig. 2. I-Attend database design

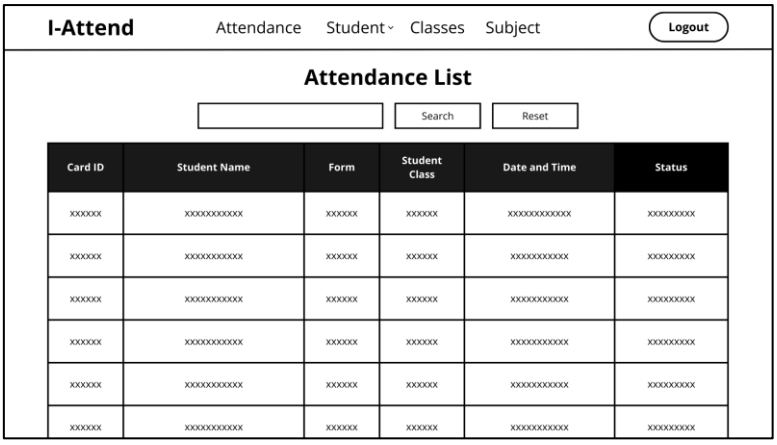

Fig. 3. Student attendance list page prototype

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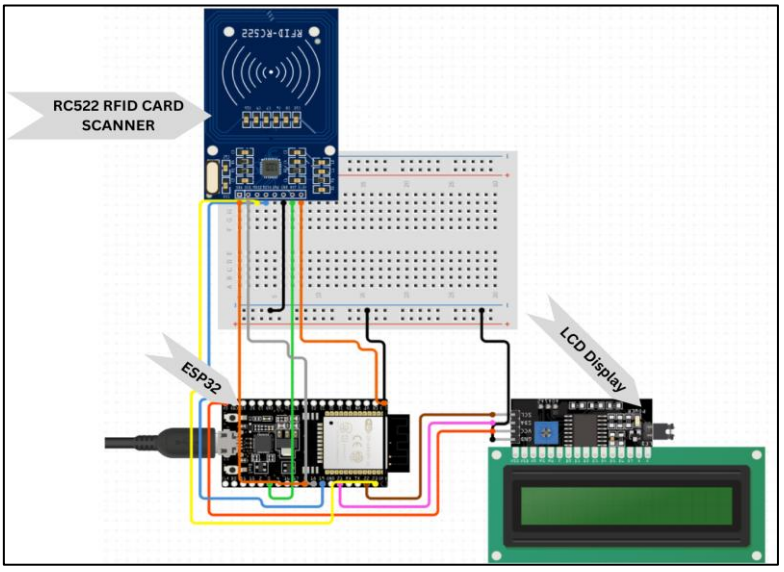

Fig. 4. Hardware schematic diagram

The design phase will guide the creation of the third phase of the I-Attend project, ensuring its successful completion. Several pieces of software will be used to successfully develop the system and hardware, which are Arduino IDE and Visual Studio Code. The programming languages chosen are C++, HTML, and JavaScript. Fig. 5 and 6 below show an example of a programme code to develop the I-Attend project. The student's attendance will be stored in Firebase as shown in Fig. 7, and then the administrator and teacher can view student attendance records via the I-Attend system as shown in Fig. 8 and 9. Therefore, objective two of the project, which is to create a smart attendance system for secondary schools using RFID technology, has been achieved by completing the development phase.

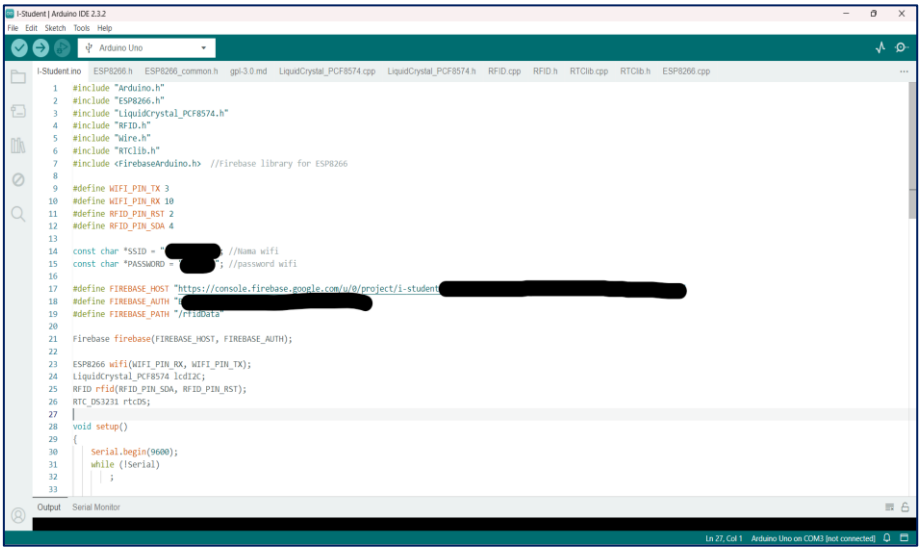

Fig. 5: Sample of Code

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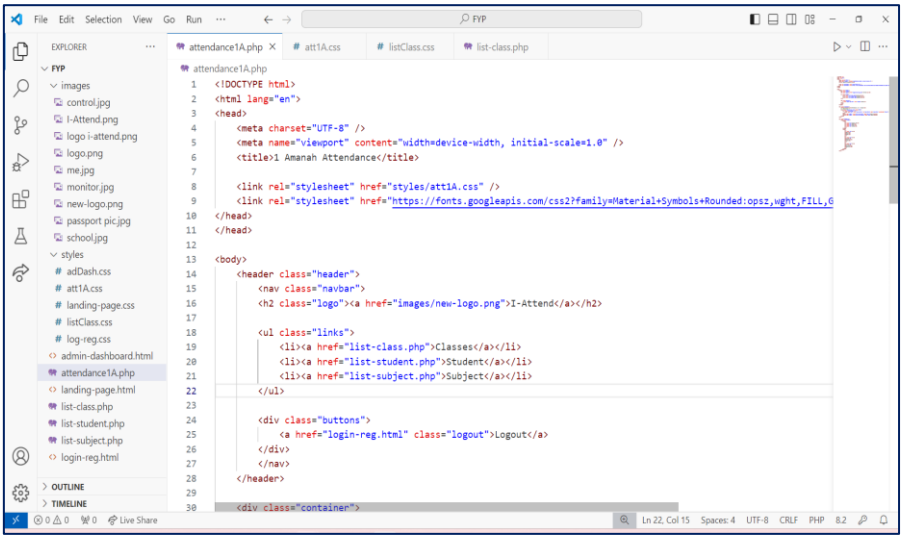

Fig. 6. Sample of HTML Code

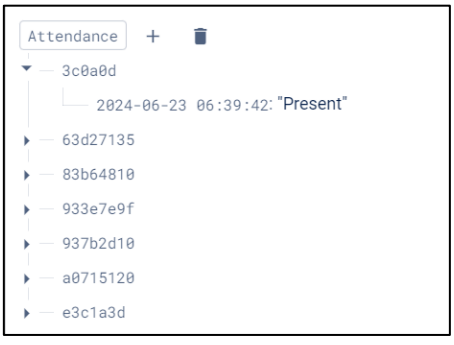

Fig. 7: Sample database in Firebase

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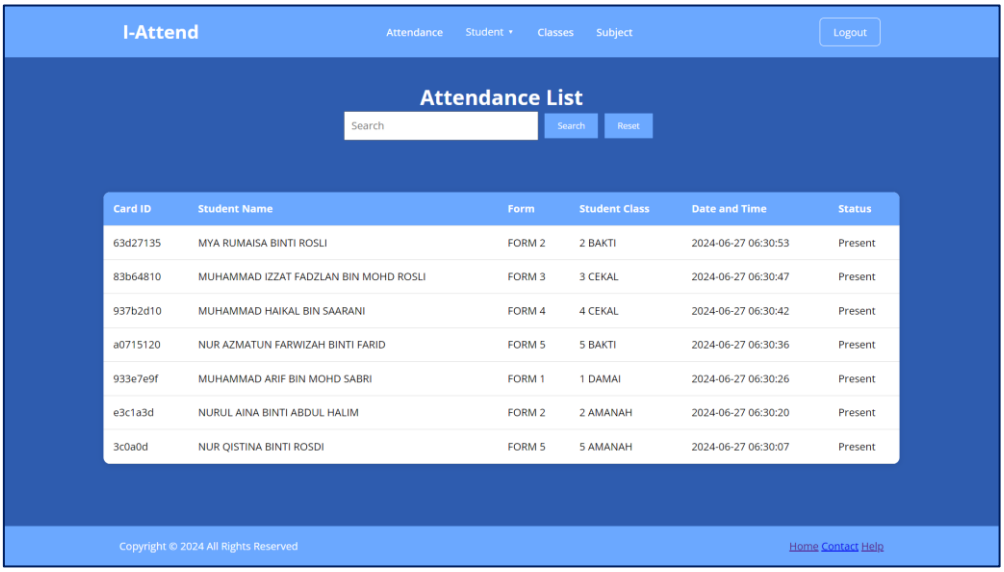

Fig. 8. Student attendance list interface for Admin

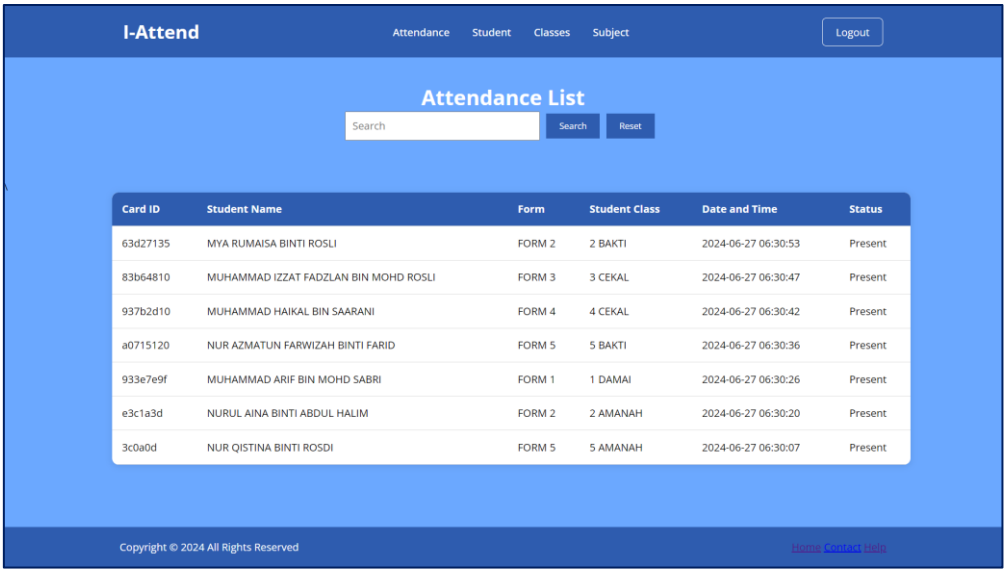

Fig. 9. Student attendance list interface for Teacher

Testing is the fourth stage of I-Attend's development process. The system's testing process will include both functional and usability testing. An analysis of users' comments would be conducted to determine whether the system aligns with the project's user requirements and objectives. In this phase, objective three, which is to evaluate the functionality and usability of the I-Attend Web Application System, is achieved.

Documentation is the final phase of I-Attend's development. The first phase, which will continue until the testing phase, entails documenting all relevant information about the project's development. To

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complete the report, Microsoft Word is used as the report's documentation tool. This phase will be the final step in completing the development of this I-Attend project.

4. RESULTS AND DISCUSSIONS

Once the design and development phase are completed, the next step would be the testing phase. As per the project objectives, I-Attend will employ functionality and usability testing to examine how users interact with the system. Functional testing is a type of testing that ensures that the system's functionality and features align with the functional and user requirements (Hypertest, 2024). Usability testing is a type of user research that evaluates the user experience when interacting with the web application system (User Testing, 2024).

4.1 Functional Testing

A test criterion, also known as a test case, was prepared for the functionality testing process. The testing would involve three roles, which consisted of an administrator, a teacher, and a student. The selection of the administrator and teacher participants came from SMK Dato Sheikh Ahmad in Arau, Perlis, while the student participant was chosen from Universiti Teknologi MARA in Arau, Perlis. Prior to undertaking the test, the participants would be provided with a sample test case. Participants would use the I-Attend Device and I-Attend Web Application System, then check the sample test case provided.

4.1.1 Administrator

The test case diagram for functionality testing of the I-Attend Web Application System allows administrators to exercise control, monitor, and track student attendance, student information, classes, and subjects by performing operations such as creating, reading, updating, and deleting information. Table 1 displays the individual stages for the administrator to test 96 instances, while Table 2 shows the corresponding outcomes for each step.

Table 1. Test case diagram for Administrator

Project Name: I-Attend: A Smart Attendance System for Secondary Schools using RFID and Firebase	
Test Case	
Module Name: Administrator	**Test Execute by:** Nur Izzati binti Sabri
Test Title: CRUD Function	**Test Execution data:** 24/6/2024
Description: User attempts to add, view, update, and delete student information.	

Table 2. Result test case diagram for Admin

Test Steps	**Test Data**	**Expected Result**	**Actual Result**	**(Pass/Fail)**
Login with correct email, password, role	nurizzatisabri93@gmail.com 123456 Admin	Successful	Successful	Pass
Login with incorrect email, password, and role	nurizzatisabri93@gmail.com 654321 Teacher	Failed	Failed	Pass
View list of students	nurizzatisabri93@gmail.com 123456 Admin	Successful	Successful	Pass
Delete student information	3c0a0d Nurul Afiqah Azri binti Mazlan Form 1 1 Amanah Female	Successful	Successful	Pass

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	Bukit Jalil, Kuala Lumpur Jamaliah binti Mohamad Ali 019-9064603 Maznita binti Addul Talib			
Add new students	3c0a0d Nur Qistina binti Rosdi Form 5 5 Amanah Female Tanjung Malim, Perak Rosdi bin Manap 019-4543160 Maya Anith binti Harun	Successful	Successful	Pass
Update student information	3c0a0d Nur Qistina binti Rosdi Form 5 5 Amanah Female Tanjung Malim, Perak Rosdi bin Hanafi 0194543160 Maya Anith binti Harun	Successful	Successful	Pass

According to the administrators' functionality testing, the participant was expected to have successfully completed all of the tests assigned. If the participant supplied an incorrect email, password, or role, the system could not be accessed, as stated in the predicted results row. The participant was also capable of executing view, add, update, and delete operations for student information.

4.1.2 Teacher

The test case diagram for teachers, as shown in Table 3, allows teachers to monitor only student attendance, student information, classes, and subjects. For the teacher's test case, the participant needed to login with correct and incorrect user credentials. The participant also needed to test the search box provided on the student attendance page and student information page. The participant must complete the provided steps, and the results are displayed in Table 4.

Table 3. Test Case Diagram for Teacher

Project Name: I-Attend: A Smart Attendance System for Secondary Schools using RFID and Firebase	
Test Case	
Module Name: Teacher	**Test Execute by:** Md Rosdy Yaakob
Test Title: Component Testing	**Test Execution data:** 24/6/2024
Description: User attempts to log in with correct and incorrect user credentials and view attendance.	

Table 4. Result Test Case Diagram for Teachers

Test Steps	Test Data	Expected Result	Actual Result	(Pass/Fail)
Signup full name, email, password, and role	Md Rosdy Yaakob mdrosdy69@gmail.com 123456 Teacher	Successful	Successful	Pass
Login with correct email, password, and role	mdrosdy69@gmail.com 123456 Teacher	Successful	Successful	Pass
Login with incorrect email, password, and role	mdrosdy69@gmail.com 123456 Admin	Failed	Failed	Pass
View attendance list	mdrosdy69@gmail.com	Successful	Successful	Pass

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	123456 Admin			
Search “Adam” in the search box	Adam	Failed	Failed	Pass
Search “Rosli” in the search box	Rosli	Successful	Successful	Pass

According to the teacher’s test case results, the participant demonstrated the ability to effectively finish the test. The participant encountered a login failure due to incorrect user credentials and proceeded to search for the name “Adam” in the search field on both the student 99 attendance page and the student information page. This discrepancy arises due to a lack of correspondence between the user’s authentication and the data kept in the database. The participant encountered no results when searching for the term “Adam” in the search box. This is because “Adam” was not listed in the student attendance or information database.

4.1.3 Students

For this project, one student would test the I-Attend device. To record attendance, the participant would only need to touch the RFID card or RFID keychain tag on top of the scanner. Table 5 shows the steps for conducting the testing, while Table 6 shows the test case’s results.

Table 5. Test Case Diagram for Student

Project Name: I-Attend: A Smart Attendance System for Secondary Schools using RFID and Firebase	
Test Case	
Module Name: Student	**Test Execute by:** Muhammad Haznor Haqiff bin Hamam
Test Title: Device Testing	**Test Execution data:** 26/6/2024
Description: To record attendance, the student attempts to touch the RFID card or keychain on the scanner.	

Table 6. Result Test Case Diagram for Student

Test Steps	Test Data	Expected Result	Actual Result	(Pass/Fail)
Touch RFID card or RFID keychain to the device	3C0A0D	Successful	Successful	Pass

Based on the results for the functionality of the I-Attend Device, the participant was able to record attendance using the device. The test data was successfully stored in the database and displayed in the system after the participant touched the RFID card on top of the RFID scanner. This shows that the device worked as expected.

4.2 Usability Testing

The respondents for the usability testing were chosen based on their expertise in software, ICT administration at SMK Dato Sheikh Ahmad, Arau Perlis, and ICT administration at Universiti Teknologi MARA, Arau Perlis. The purpose of this test is to assess the respondents’ ability to navigate and successfully complete the activities with ease. Each respondent must complete the usability testing questionnaire using a rating scale ranging from 1 to 5. Table 7 shows the scale’s evaluation using the next range. Table 8 displays a number of questions that are given to the respondents.

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Table 7. Scale range

Scale	Description
5	Strongly agree
4	Agree
3	Neutral
2	Disagree
1	Strongly Disagree

Table 8. Result of Usability Testing

No.	Question	1	2	3	4	5	Mean
1.	I think that I would like to use the I-Attend.	0	0	0	3	4	4.57
2.	I found the I-Attend to be a very complex web application system.	0	0	1	3	3	4.29
3.	I thought the I-Attend was easy to use.	0	0	0	2	5	4.71
4.	While using the I-Attend, I don't think that I need technical assistance.	0	0	0	3	4	4.57
5.	I found that various functions in the I-Attend are well integrated.	0	0	0	2	5	4.71
6.	I-Attend's design and interface are very consistent.	0	0	0	1	6	4.86
7.	The processes and activities provided by the I-Attend are easy to learn.	0	0	0	1	6	4.86
8.	I felt very confident and comfortable using the I-Attend.	0	0	0	1	6	4.86

Fig. 10 analyses the mean for usability testing based on Table 5.3. The bar chart shows that questions six, seven, and eight have the highest mean (4.86). According to this mean, the majority of the respondents feel that it is easy to do activities while using I-Attend. Respondents also feel confident and comfortable while using the system, and they feel that the interface is consistent across the system. Questions three and five each have a mean of 4.71. Most respondents thought that I-Attend was easy to use and that the functions were well integrated. Next, questions one and four each have a mean of 4.57. It can be seen that respondents think that they like to use I-Attend and that this system does not require technical assistance to use. Finally, question two has a mean value of 4.29. This shows that respondents feel I-Attend is a very complex web application system.

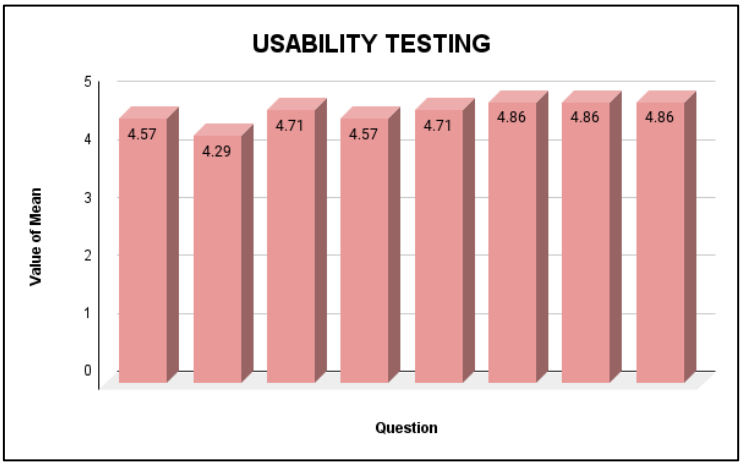

Fig. 10. Mean of Usability Testing

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Furthermore, another set of usability tests was conducted. The respondents were provided with a series of questions to reply to using concise answers. Table 9 displays the examination questions, whereas Table 10 presents the responses provided by all respondents.

Table 9. Test Questions for Usability Testing

No.	Question
1	During the test, how would you describe your overall experience with the system?
2	Did you find the RFID-based attendance tracking feature intuitive and easy to use?
3	What features or elements stood out positively or negatively?
4	Were you able to navigate through the system easily?
5	Please share any additional comments or suggestions you may have for enhancing the user experience.

Table 10. Answer test Questions for Usability Testing

Question	1	2	3	4	5
Participant					
1	Very good	Very easy to use and makes it easier for admins and teachers to monitor student attendance	An interesting positive element in this system is the attendance of students using RFID cards	The system is easy to use	The attendance list should be displayed by day, and past records can be accessed through the filter function for admin or teacher.
2	The system can potentially go further	Yes, easy to use very helpful	Yes, positive	so far, easy to understand	The system dashboard needs to be improved for better organisation and student attendance display, and the use of HTML should be switched to a more secure language.
3	Very useful to use. Makes data easy to find	Yes	Positive	Yes. easily accessible	Very good system. Can be expanded further
4	The best	Very easy to use	Yes	Yes	Keep doing projects like this
5	Smooth and database is working	It is easy as long as you possessed the card/token	A bit tutorial on how to use the system would be very helpful	No at initial attempt	A bit tutorial or some guidance to help teachers use feature (example: tap RFID to record attendance)

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6	My overall experience with the RFID attendance system was very positive. It's an interesting and efficient tool that significantly simplifies managing student attendance in real-time, especially for teachers.	Yes, the RFID-based attendance tracking feature is intuitive, easy to use, and operates in real-time, making it highly effective for monitoring student presence seamlessly.	A standout feature is the real-time data recording, allowing teachers to access the latest student attendance information online. This immediacy is incredibly beneficial for managing classroom activities and ensuring accurate records, positively enhancing the overall efficiency and reliability of the attendance system.	Yes, navigating through the system was easy due to the simple and user-friendly interface, making it straightforward to understand and operate.	To enhance the user experience, I suggest improving the display of detailed student information. Adding a filter by class would greatly assist teachers and admins in easily locating and managing student data, making the system even more efficient and user-friendly.
7	Very good	Yes, very easy to use	The most prominent feature is the recording attendance data in real-time using RFID	Yes, the system is easy to navigate	The attendance list page should include filter and sort features. The help page should also include images.

Based on the data in Table 10, most respondents expressed satisfaction with their overall experience when using the I-Attend system. Respondents noted that the attendance monitoring tool based on RFID technology was simple to use. Furthermore, respondents also expressed that a notable aspect of I-Attend is its capability for instantaneous data retention, which aids in the effective organisation of classroom activities. Another notable feature is the ability to record attendance using RFID cards. Nevertheless, a respondent asserts that instructions are needed in order to proficiently navigate users through the I-Attend system. Furthermore, the majority of respondents reported that I-Attends was user-friendly, while one respondent initially encountered difficulties navigating the system.

Finally, some suggestions and comments were provided by the respondents to improve the usability of the I-Attend. Several respondents suggested that the I-Attend system can be further improved by including a filter option for previous attendance records and showing a list of attendance by day. Furthermore, a respondent recommended updating the dashboard and list of attendance to make them more systematic, as well as using a different programming language to enhance security. Moreover, one respondent suggested adding tutorials or guidelines to help teachers use some features on the I-Attend. Next, a respondent proposed enhancing the student information details by categorising student information by class, which would not only assist the admin and teacher but also improve the user experience. Finally, the last respondent suggested that visual aids be included on the help page. Based on the suggestions provided, some suggestions from the respondents have been implemented in the I-Attend Web Application System.

5. CONCLUSION AND RECOMMENDATIONS

The development of the I-Attend represents the advancement of automated attendance management systems for secondary schools. By implementing RFID technology, I-Attend effectively addresses the inefficiencies and inaccuracies associated with manual attendance record methods. The successful implementation and positive user feedback demonstrate that I-Attend is practical and user-friendly. I-Attend not only

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demonstrates the feasibility of such a system, but also highlights its potential to enhance administrative efficiency and accuracy in the education sector. Future research could explore integrating the system with broader school management platforms and expanding its functionalities to further benefit users.

To overcome the limitations of the project "I-Attend: A Smart Attendance System for Secondary Schools using RFID," some recommendations are planned to improve the system's functionality and usability. The first recommendation is to enable the RFID card to store student information. This will reduce reliance on Firebase and help to resolve issues during unstable internet connections. On the "Subject" page, some functionality can be implemented by adding the ability to assign teachers to the subjects, link subjects to specific classes, give homework to students, and grade students' assignments. Finally, to address control measure issues, the specific permissions to access student information have been enhanced by defining clear roles for users such as administrator, homeroom teacher, and subject teacher. This reduces student privacy data leaks and ensures that each role can only access assigned data.

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