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NFC-BASED MOBILE ATTENDANCE APPLICATION IN MALAYSIAN HIGHER EDUCATION: EASCON DEVELOPMENT AND USABILITY EVALUATION

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Abstract:

Nowadays, the utilisation of cutting-edge technologies for tracking and monitoring attendance records is prevalent. Despite the availability of sophisticated systems or tools such as biometric devices, many institutions, including those in Malaysian higher education, still rely on manual attendance tracking methods, leading to numerous issues. In contrast, Near-Field Communication (NFC) technology offers a more economical alternative. This study introduces EASCON, a cost-effective NFC-based mobile attendance application designed for the Malaysian higher education ecosystem. To design and develop EASCON, Software Development Life Cycle (SDLC) methodology via waterfall approach was employed. It involves six or seven stages depicting the procedures that must be taken for a successful software production. The data modelling designs of EASCON along with the system architecture and user interface are presented in this study. The functionality and usability of EASCON have been evaluated among 30 prospective users via System Usability Scale (SUS) questionnaires with the final average score of 71.8. This shows the potentials of EASCON as an efficient tool for attendance tracking and monitoring in Malaysian higher education institutions, thus achieving the objective of the study. Recommendations for EASCON future enhancements are also presented in this paper.

Keywords:

Attendance Tracker, Mobile Attendance, Mobile Attendance Application, Near-Field Communication, NFC Tags

Introduction

The use of state-of-the-art technologies in tracking and managing attendance records is very common nowadays. From the biometric recognition to the deployment of certain wireless devices, attendance tracking has been thought to be challenging especially in dealing with typical human errors and error-prone situations. At the same time, there are still several institutions that utilise the manual approach of attendance tracking due to various constraints, hence providing countless successive issues (Masruroh, 2018; Nasir et al, 2015). This scenario also happened in the Malaysian higher education setting where it would usually involve students, instructors and administrators.

On the other hand, as the technology advances, more and more devices are being introduced for attendance tracking and monitoring purposes. This includes the use of mobile devices such as smartphones that are equipped with wireless data transmission technologies. One of the associated technologies is Near-Field Communication (NFC). NFC is commonly used in mobile payment and access control applications whereby it is deemed to be convenient and beneficial to users. Even so, the use of NFC for attendance tracking especially in Malaysian context is still undetermined though it could offer various potentials (Zay et al., 2016; Shuen, 2022).

The manual attendance tracking poses challenges in maintaining operational efficiency and obtaining accurate data in real-time situations (Nasir et al, 2015; Benyo, 2012; Masruroh, 2018; Ayu & Ahmad, 2014). The instructor may have to accommodate his class's time in either calling out each student's name to mark the attendance or distributing the attendance tracking paper to the students for their signatures. As an alternative, the instructor may also provide the students a link to the online form for attendance tracking. Nonetheless, this approach still requires the instructor to manually key-in the attendance information into the institutional system. Mistakes could happen while entering the data, thus providing inaccurate attendance records. To overcome this issue, automation is required for improving the operational efficiency.

Implementing modern technology such as biometric devices could ease the process of attendance tracking. Fingerprint scanner and facial recognition are the examples of typical biometric devices. These devices use biometric sensors for capturing the user's identification, thus ideally could track the attendance in effective ways. However, the implementation of these devices is costly and may not be suitable for the learning institutions. Ongoing maintenance is also required since the devices could also be susceptible to damages especially when dealing with many users in the same period. Hence, a more realistic and less expensive approach is recommended.

With the current technology in wireless transmission such as NFC, smartphones and mobile applications, the automation of attendance tracking is possible to be done. This option is deemed to be cheaper than the other automation technologies (Zay et al., 2016; Vaqari et al.,

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2023) due to its potential for widespread utilisations as majority of people owns a smartphone that is connected to the mobile network. Furthermore, NFC is also possible to be used among students via their NFC-enabled student identification cards, thus providing a great accessibility throughout the campus. Therefore, this study intends to design, develop and evaluate the NFC-based mobile attendance application while selecting the institution of Malaysian higher education as the focus of the study.

Literature Review

There are two topics to be discussed in this section which are Near-Field Communication (NFC) technology in education sector and related works.

Near-Field Communication (NFC) Technology in Education Sector

Near Field Communication (NFC) is a wireless technology that facilitates short-range communication between devices. It operates at the frequency of 13.56 MHz and is founded on Radio Frequency Identification (RFID) technology. NFC establishes a wireless connection by utilising electromagnetic radio impulses when two devices are in close proximity. This technology has emerged as a significant technology that can facilitate a wide variety of applications, including mobile payment, transit ticketing, and access control.

NFC enables devices to communicate through two distinct operation modes: active and passive (Haselsteiner & Breitfuß, 2006). In active mode, both devices generate their own radio frequency (RF) fields, allowing for bidirectional communication between them. This mode is typically used when both devices are capable of powering their RF signals. Conversely, in passive mode, one device, known as the active device, generates the RF field, while the other device, referred to as the passive device, relies on this field for communication. This mode is used when one device cannot generate its own RF field and instead utilizes the field created by the active device. During communication, the device initiating the exchange is called the Initiator, while the device that responds and acknowledges the request is called the Target (Motlagh, 2012). It is important to note that once a communication mode is established, it cannot be changed until the session ends; however, transmission speeds can be adjusted through a parameter change procedure. Since active mode requires substantial energy, it is generally more practical for battery-powered devices, such as mobile phones, to operate in passive mode to conserve power.

Operationally, there are three communication modes of NFC which are read/write, peer-to-peer and card emulation modes. The definition and difference between these modes are explained in the Table 1 below. With the capabilities of the current smartphones, all three modes are possible to be utilised for successful NFC operations.

Table 1: NFC Communication Modes and Applications

Modes	Descriptions	Examples of Applications
Read/Write	NFC-enabled devices read and write data to NFC tags or other NFC-enabled devices	Smart posters and inventory management
Peer-to-peer	Two NFC-enabled devices exchange data without the need for pairing or configuration	Photo sharing and contact sharing
Card emulation	NFC-enabled devices act as a contactless card for performing transactions	Mobile payments, ticketing and access control

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As a straightforward and efficient method of data transfer between devices, NFC technology has the potential to improve a variety of educational mechanisms such as attendance tracking (Ali et al, 2022; Vaqari et al., 2023; Shuen, 2022; Zay et al., 2016; Benyo et al., 2012; Bueno-Delgado et al. (2012); Jacob et al., 2015; Mohandes, 2017; Baykara et al., 2017), mobile learning (Shawai & Almaiah, 2018; Tabuenca et al., 2014; Shawai et al., 2015; Cheong et al., 2013), library management (Kazi et al., 2024; Mun et al., 2018) and access control systems (Bransfield, 2020; Mansur et al, 2018; Hattersley, 2011). Most of the previous studies have shown the feasibilities of NFC in enhancing the tasks and operational management in learning institutions. It is expected that the technology would continue to be experimented within the education settings along with other technologies such as Internet of Things (IoT).

Related Works

There are various studies that have been conducted in utilising NFC for student identification and attendance tracking. Bueno-Delgado et al. (2012) and Ayu and Ahmad (2014) have suggested the uses of NFC beam for data transmission between the student's mobile phone and the instructor's mobile phone for recording attendance records. In order to allow this operation, the student was required to login to the server first before touching his or her device to the instructor's device. This process is deemed to be impractical and tedious when dealing with many students concurrently in the same classroom. The students must continually login with their login ID and password for each lecture and also ensure that their mobile phones are always functional. This issue could also occur in a study by Shuen (2022) who proposed the uses of student's smartphone as the digital ID to replace the physical ID card.

On the other hand, a mobile system by Masruroh et al. (2018) integrates the uses of images or face recognition for student's verification along with a web application for generating attendance reports. This approach was also being implemented by Wani et al. (2014) and Sayanekar et al. (2016) via the applied NFC reader. The students need to tap the NFC reader and capture his or her image for the details to be stored inside the database. The acquired details would later be shown on the web app for monitoring purposes by the instructors. Nonetheless, this process that includes the face recognition mechanism may be wearying and time-consuming whilst dealing with large number of students at the same time. An additional camera is also required for the system to be fully operational, thus increasing the installation cost.

A study by Benyo et al. (2012) utilised NFC-enabled embedded devices for attendance tracking and monitoring in Budapest University of Technology and Economics. The study also incorporates the uses of biometric devices such as fingerprint reader together with the student identification cards. The fingerprint reader would act as the NFC contactless terminal that could accept both data from student cards and fingerprints. Although this solution is good in minimising the risks of truancy, its installation and maintenance are costly due to having numbers of device terminals.

After considering the issues in previous works, this paper presents a simple and inexpensive NFC-based mobile attendance application called EASCON with the utilisation of NFC-embedded student ID cards and the instructor's NFC-enabled smartphone that will act as the NFC reader. The attendance data will be recorded in the database and the details will appear in the mobile and web-based applications for the purpose of reviewing and monitoring. The potential users of EASCON are students, administrators, lecturers and parents.

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Methodology

To design and develop EASCON, Software Development Life Cycle (SDLC) via waterfall approach was employed. SDLC is known to be a robust and well-received methodology in understanding the process of software development. It involves six or seven stages depicting the procedures that must be taken for a successful software production. Primarily, the significant stages of SDLC are requirements analysis, planning, software design, software development, testing and deployment (Alexandra, 2024; Tozzi, 2024). Another stage which is maintenance could also be included to complete the lifecycle of the software production.

Through SDLC, various development approaches or models have been developed to accommodate the different needs and criteria of software development. Examples of these models include waterfall model, prototyping model, agile model and spiral model. Each model is targeted for specific conditions and goals in developing a successful software. In this study, waterfall model is chosen due to its suitability to the context of study.

The waterfall model, proposed by Winston Royce in 1970s for software project management (Lteif, 2024) is straightforward, easy to use, and manageable since each step has clear outputs and assessments (The Economic Times, 2024). In addition to this, it contains specific phases, which are useful for smaller projects with definite requirements. Each phase will be documented, thus providing insightful details for future references. Figure 1 shows the current and updated waterfall model that has been utilised in this study. The updated waterfall model has included iterative approaches at each stage for reaching the project goals.

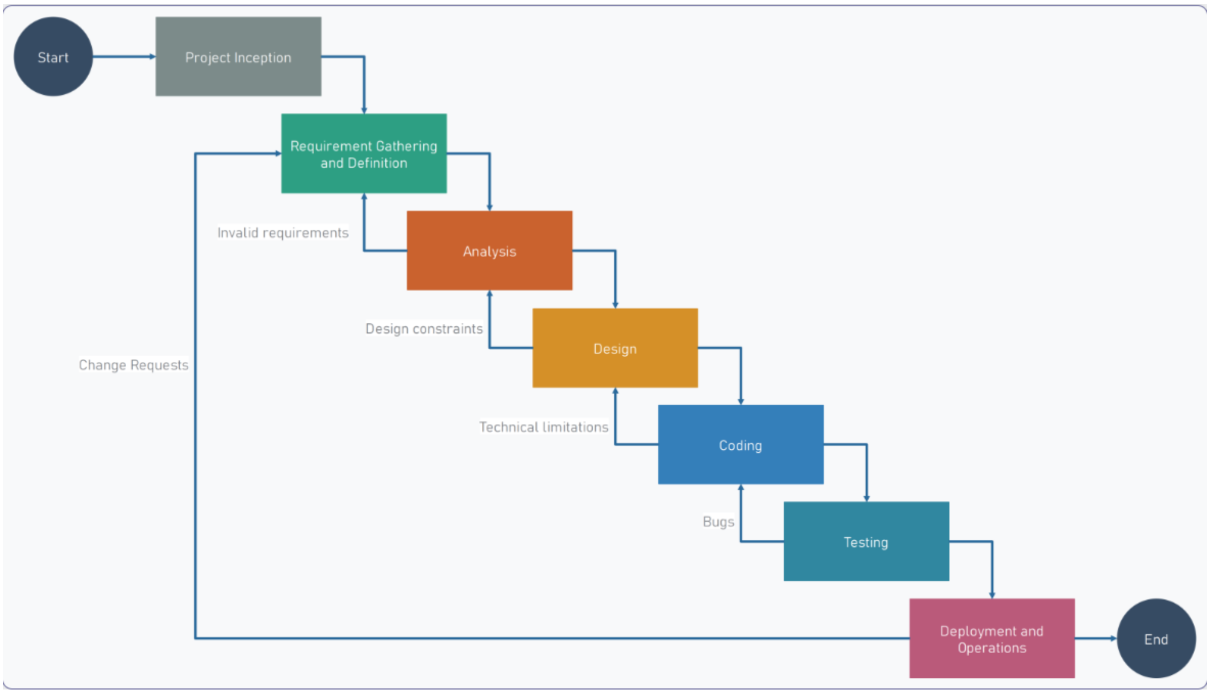

Figure 1: Latest Version of Waterfall Model

Source: Lteif (2024)

In the project inception phase, the preliminary study was conducted in understanding the needs of automated attendance in Malaysian higher education setting. Interviews have been performed with several instructors and administrators in order to acquire the initial information and issues related to the attendance tracking and monitoring. For this study, the selected case

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study is UiTM Cawangan Terengganu Kampus Kuala Terengganu. Issues such as truancy, inefficient manual attendance tracking, and the uses of paper-based attendance recordkeeping were identified during the interviews. The interviewees were also asked about their requirements and expectations of the upcoming automated attendance tracking system. Based on the consensus, mobile attendance application with the integration of NFC technology is deemed to be the most suitable in the current situation due to its feasibility, practicality and inexpensiveness. The NFC-based mobile attendance application is named EASCON to represent the "easy condition" of automated attendance tracking and monitoring.

After the preliminary study, the second stage was executed whereby all requirements of EASCON were gathered including the user requirements, functional requirements, non-functional requirements, data requirements and system requirements. The summary of user, functional, non-functional and data requirements of EASCON is presented in Table 2 whilst the EASCON system requirements for development is presented in Table 3.

Table 2: Summary of User, Functional, Non-Functional and Data Requirements of EASCON

Requirements	Descriptions
User Requirements	Automated attendance record, simple and user-friendly login, simple user interface, simple procedures to reset passwords or usernames, fast response to user requests, attendance notification and summary report/information generation
Functional Requirements	New student registration, student login, lecturer's ability to add or delete courses and students, system's ability to read NFC cards to save attendance information, and system's ability to retrieve information when required by lecturer, parent, or students
Non-Functional Requirements	Security, efficiency, simplicity of interfaces, flexibility, and accuracy
Data Requirements	Lecturer identification numbers, course information (i.e., course ID number, course name, course date), student information (i.e. student names, ID numbers, NFC card, and attendance report), and other required data

Table 3: EASCON System Requirements for Development

Requirements	Descriptions
Hardware	<u>Laptop Specification</u> Model: Asus Processor: Nvidia RTX 1650 Operating system: Windows 11 Pro Memory: 12 GB RAM Storage: 1 TB System Type: 64 – bit
	<u>Card</u> Near-Field Communication (NFC) Card
Software	<u>Android Studio</u> Version: Latest Version Programming Language: Java
	<u>Visual Studio Code</u>

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	Version: Latest Version Programming Language: HTML, CSS, PHP, and JavaScript
	Firebase and SQLite Version: Latest Version Description: For the database of the application
	Canva Version: Latest Version Description: For user interface design

All the requirements were then analysed and reviewed for the finalisation of EASCON requirements before entering the design phase. Usually, the requirements gathering and analysis phases occurred concurrently through series of reviews and feasibility studies.

Next, the design phase took place where the data modelling and system architecture blueprints were presented based on the previous requirements analysis results. For this study, context diagram, data flow diagram, entity-relationship (ER) diagram and system architecture diagram were used to simulate the operational functions of EASCON which were useful for the development or coding process. Figure 2 illustrates the context diagram of EASCON to signify the data flows and interactions between EASCON users and the application itself.

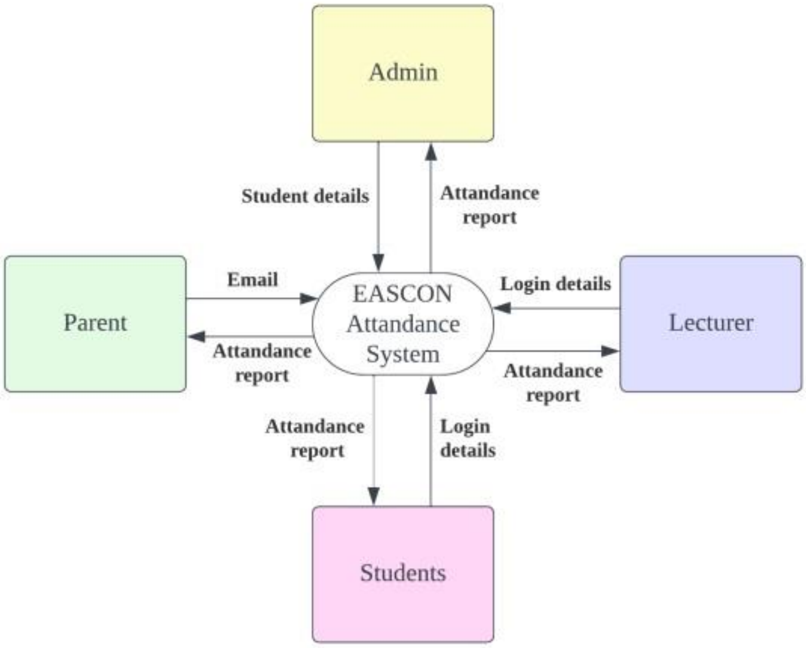

Figure 2: Context Diagram of EASCON

On the other hand, Figure 3 depicts the system architecture of EASCON, outlining its primary components and structure. NFC tags in both student ID cards and lecturer's smartphone, play a crucial role in EASCON ecosystem as they are powered electromagnetically by induction. NFC-enabled devices may read student's data that is stored in a small format, allowing for easy storage and accessibility. While it is possible to configure the tags to be rewritable on occasion, they are often designed to be read-only. NFC tags in the microchip have varying storage capacities, ranging from 48 bytes to 32 kilobytes, depending on the type of tag.

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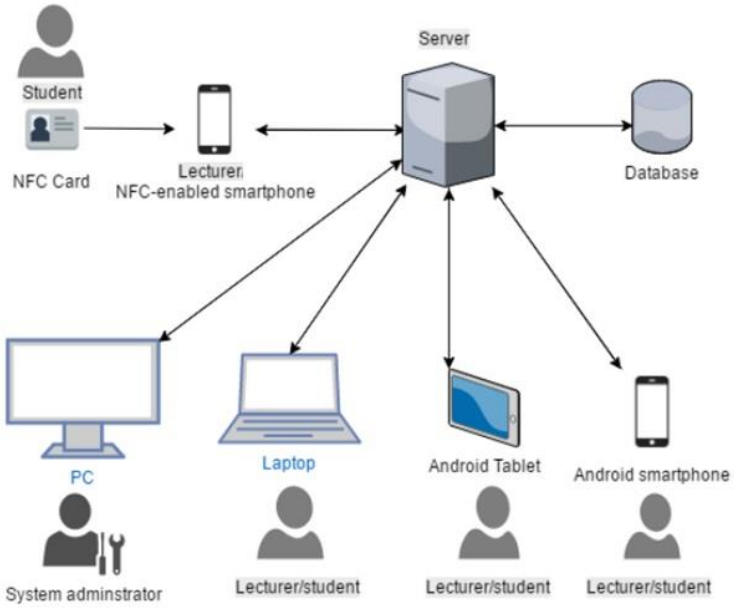

Figure 3: System Architecture of EASCON

The development of EASCON was done through Android Studio, Visual Studio Code and Firebase and SQLite applications along with programming languages specifically Java, PHP, HTML, CSS and Javascript. It involves the actual implementation of NFC-based hardware and software in the system that includes both EASCON installation and configuration. For storing attendance records, Firebase and SQLite were utilised to create a functional database accompanied by NFC tags and readers. EASCON development also included a set of workstations together with a personal computer (PC), a laptop and several smartphones for testing purposes.

In the testing phase, the functionality and usability of EASCON were conducted to ensure the successful operations. Test plans were prepared and utilised by both developer and tester for evaluating the EASCON functionality. Table 4 shows the sample of test plan for testing the admin's operations in EASCON. For the usability evaluation, System Usability Scale (SUS) was used via distribution of questionnaires to 30 potential users during the deployment stage. The results will be presented and discussed in the later section of this paper.

Table 4: Test Plan Sample for EASCON Admin's Operations

No	Requirement	Result	Developer	Tester
1.	Enter username and password. ➢ If the username or password is wrong, system will pop up message and return to login page	Main page		
2.	Click main menu	Main page		
3.	Click add student button	student page		
4.	Click add course button	course page		
5.	Click find student	Student details page		
6.	Click show student button	Student attendance		
7.	Click confirm button	The detail is confirmed, the application will notify the parent and student		

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EASCON Procedures and Deployment

In order to understand the operationalities of EASCON, a scenario is given where each student will be given a student ID card with an embedded NFC chip. Every NFC tag possesses a unique identification due to its exclusive serial number. Each student's information is printed on an individual tag for easy scanning by the EASCON mobile app. For the first-time user, students or lecturers need to register and create a new account. Then, the students may conveniently log their attendance by utilising an NFC-enabled Android smartphone and EASCON.

For students to record their attendance, a lecturer must initially access EASCON and begin an attendance marking session. Once the lesson finishes and all attending students have verified their attendance by tapping their ID cards on the lecturer's smartphone, the lecturer will conclude the session. A notification will appear on the smartphone to inform the successful attendance marking. Additionally, the absenteeism report will be sent to the parents via e-mail notifications.

The server enables the dissemination of content online by responding to enquiries in EASCON. Data obtained from the application and the website, such as timetables, courses information and student records, are kept in a database. Hence, the users such as administrators and lecturers will have the capability to execute queries on the database and get the required information. The process involves compiling a summary of attendance data for a class or an individual student. For flexibility, EASCON can be accessed via web browsers in desktop computers, laptops, tablets, and smartphones. Meanwhile, the mobile app is available to be downloaded and installed for Android smartphones and tablets users.

EASCON Mobile User Interface

After downloading and installing EASCON, each new student, lecturer or admin must register to create an account. Figure 4 shows the user interface for registration. The users must key-in their active e-mail address and password in which to be used later for EASCON login purposes. They must also select their role as a student, a lecturer or an administrator.

After the registration, the details will be verified by the admin, and a new account will be created. The new user needs to login to EASCON via the login interface illustrated in Figure 5.

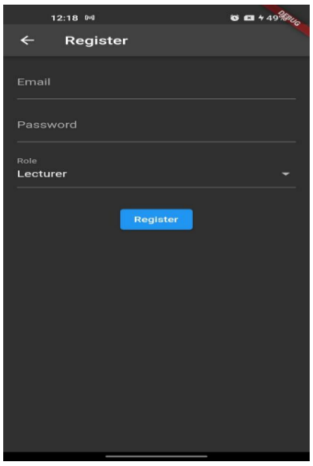

Figure 4: EASCON Registration User Interface

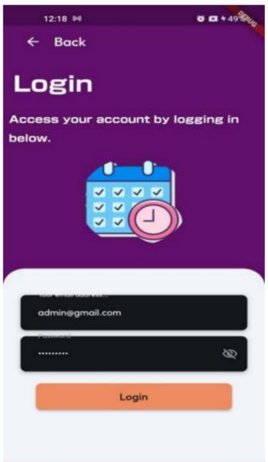

Figure 5: EASCON Login Interface

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As EASCON app will be mostly used by the lecturer for tracking the students' attendance of each lesson, the lecturers will have a more comprehensive menu in their app than the students. For students, they can only view their previous attendance records and update their profiles. On the other hand, lecturers can use their account to manage attendance, view student profiles, and track the academic progress. The menu interface for lecturers is shown in Figure 6.

To start tracking the attendance, the lecturer must choose Attendance from the menu and select the associated class. The students will start to tap their ID cards to the lecturer's smartphone for attendance tracking. A successful attendance will be notified in green message as shown in Figure 7. Meanwhile, an absenteeism will be flagged in red notification on the list of the attendance later. At the same time, an e-mail will be sent to the parent's e-mail address to inform the absence of the student as shown in Figure 8.

Figure 6: EASCON Main Menu for Lecturers

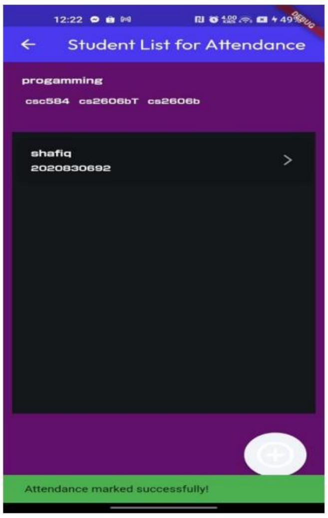

Figure 7: Example of a Successful Attendance

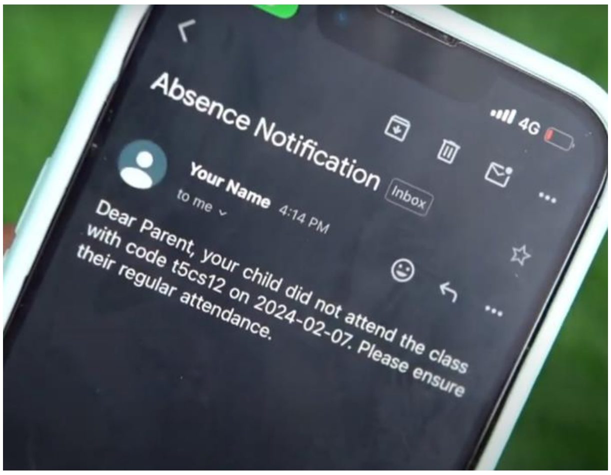

Figure 8: EASCON Absence Notification via E-mail

For the administrators, their tasks were to verify the credentials of new students or lecturers, add/edit new course details, add/edit new class information for each lecturer, add/edit students' data, match the student's data to the right class for allowing the attendance tracking and review

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the attendance reports. It is expected for the admins to add new course, class and students' information before the start of each new semester via the interfaces as presented in Figure 9 and Figure 10.

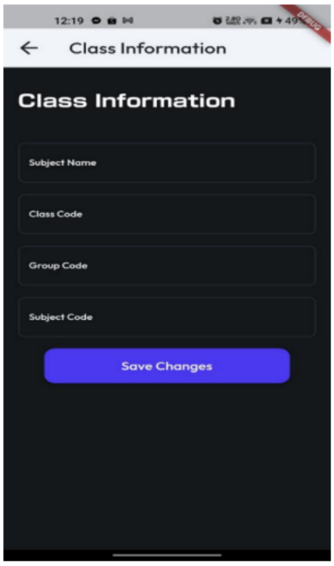

Figure 9: EASCON Add/Edit Class Information Interface

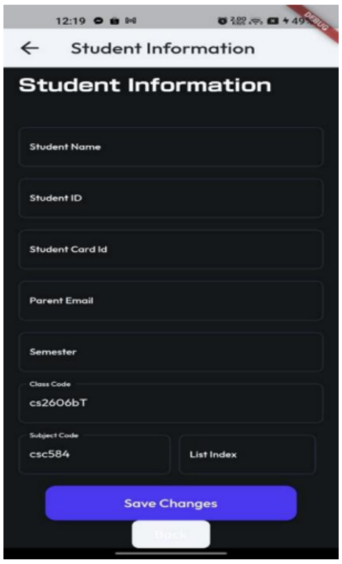

Figure 10: EASCON Add/Edit Student Information Interface

Usability Evaluation and Results

EASCON has undergone extensive testing and evaluation to verify its operation and usability, and it has shown to be successful. The application has the capability to capture the attendance of students via NFC cards, enabling both the lecturer and administrator to track and monitor the attendance within the application. If a student fails to show up in class, an absenteeism report will be automatically prepared and sent via email to the parent for their acknowledgement.

In order to evaluate the usability of EASCON, questionnaires that consist of the System Usability Scale (SUS) questions (Brooke, 1996; Sauro, 2011) were distributed to 30 potential users. These 30 respondents comprise of potential students, lecturers and administrators have provided important feedback about the EASCON usability. Table 4 shows the summary of respondents' demographic profile.

Table 4: Summary of Demographic Profiles of Respondents

Demographic	Items	Total Respondent	Percentage
Gender	Male	17	56.67
	Female	13	43.33
Age	Below 21	3	10
	21 - 25	14	46.67
	26 - 35	6	20
	Above 35	7	23.33
Position	Student	21	70
	Lecturer	6	20
	Admin	3	10

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From the Table 4, it has been identified that majority of respondents are male (56.67%) that fall under the age category of 21 to 25 (46.67%). Most of the respondents are students (70%) while the remaining 30% are lecturers and administrators.

In this study, ten system usability questions from Brooke (1996) and Sauro (2011) via five-Likert scales were used to measure the EASCON usability. From the analysis, it resulted to the SUS scores of 71.8. This result has indicated good scores of usability for EASCON as it falls above the average 68 marks or 70% (Brooke, 1996; Sauro, 2011). Hence, EASCON could be deemed as having a good functionality and usability, thus completing the objective of the study.

Recommendations and Conclusion

EASCON as the NFC-based mobile attendance application has provided a good foundation for automated attendance tracking in Malaysian higher education ecosystem. By using EASCON, students, instructors and administrators will be able to efficiently track and monitor the attendance. In addition, the parents will also get notified for any absenteeism of their children, thus encouraging the cooperation to happen between parents and institutions for avoiding truancies. Nonetheless, EASCON still has limitations that can be improved in the future.

First, it is recommended that EASCON to be integrated with the current Student Information Management System (SIMS) to facilitate the registration and login process in the future. The integration could help in extracting the information of students directly from SIMS to EASCON, hence making the operations easier. It would also ease the tasks of administrators by allowing them to only verify the current details instead of manually add all related information in EASCON.

Next, it is also suggested that EASCON to integrate with the current Class Timetable System (CTS). Similar to previous recommendation, this would ease the tasks of administrators who need to perform manual data entry about each class information in EASCON. By the EASCON integration with CTS, the class and timetable information can be directly linked to simplify the administrative tasks altogether.

Finally, EASCON is recommended to be further expanded by incorporating with state-of-the-art technologies such as Internet of Things (IoT), geolocation tracking and data analytics mechanisms. This will allow EASCON to conduct real-time tracking for enhancing accuracy and security of data. Moreover, by adding analytics tools in EASCON can assist in observing attendance patterns and trends, thus helping institutions to make the best decisions when needed.

As a conclusion, the objective of the study which is to design, develop and evaluate the NFC-based mobile attendance application has been achieved. It is known that NFC's scalability and versatility support a wide range of applications across industries, including education, retail, healthcare and transportation. Its compatibility with advanced technologies makes it a critical enabler of next generation of digital ecosystems. By seeing these potentials, it is hoped that functionalities of EASCON can be enhanced in the future to assist the institutions in Malaysian higher education sector in reducing truancies issues among students.

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