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### ENHANCING SCHOOL PICK-UP SAFETY AND EFFICIENCY THROUGH AN RFID-BASED REAL-TIME NOTIFICATION SYSTEM

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#### ABSTRACT

Heavy after-school traffic and concerns about children's safety on school premises are growing issues for guardians. To address these challenges, this paper proposes an RFID-based, role-based system that notifies guardians of their children's real-time location and alerts them when children are ready for pickup. Each student wears an RFID tag that updates their location by sending notifications to guardians' smartphones whenever the tag is scanned at the entrance or exit gates. At the same time, the system records attendance to digitise the process and ease school administrators' workload. The system also includes a scheduling function that lets clerks set the school timetable and assign teachers. This allows guardians to view their children's daily schedule, while teachers can manage their teaching plans. The team tested the prototype with experts through interviews to evaluate its functionality and user interface. Results indicate that the system delivers real-time location updates and notifications while supporting digital school operations through automated records and scheduling. In summary, the proposed system improves time management for guardians during school pick-up hours and enhances peace of mind regarding students' safety.

**Keywords:** RFID, Smart school, Internet of Things, Pick up children, Digitalisation

## **INTRODUCTION**

Nowadays, advances in Information and Communication Technologies (ICT) have significantly influenced the development of smart systems across sectors such as health, industry, and transportation. More recently, ICT has shown strong potential to transform the education sector, enhancing not only the learning process (Malawige, 2018) but also administrative operations (Ghufron, 2024) and communication between schools and guardians (Kaur & Singh, 2015).

One area of concern in school environments is the congestion and safety risks during student pick-up hours (Law et al., 2022). With increasing student numbers and limited traffic control around schools, guardians often face delays, uncertainty, and stress when picking up their children. Traditional pick-up methods provide little real-time information about a child's readiness, creating inefficiencies and safety concerns. To address this, digital solutions are needed to modernise school pick-up procedures and ensure a smooth, safe experience for both students and guardians (Law et al., 2022; Suprianto et al., 2019).

This study develops an RFID-based system to modernise the pick-up process by providing real-time notifications when a student is ready to leave. Each student carries an RFID tag that the exit gate scans, triggering an automatic alert to the guardian's mobile device. This reduces waiting times, improves traffic flow, and enhances safety.

The system is a cross-platform solution: guardians receive updates via a mobile app, while school staff use a web interface for student registration, timetable management, and record-keeping (Garcia et al., 2019). Beyond pick-up support, the system also automates attendance logs and integrates scheduling information, contributing to school digitalisation.

Through expert evaluation, this study assesses the prototype's functionality and performance and highlights how RFID technology can improve safety, efficiency, and communication in school environments.

## **BACKGROUND**

In Malaysia, the use of Radio Frequency Identification (RFID) in schools remains limited, especially at the primary and secondary levels. While SMJK Dindings in Perak piloted campus-wide RFID for attendance and security in 2004 (iSchool, 2005), adoption since then has been minimal.

A recent interview with five experts revealed that none had encountered RFID being used during student pick-up at schools. However, all had picked up a child or relative using traditional manual methods, such as visual recognition or verbal confirmation by software engineers, highlighting a clear absence of technological support in this process. All respondents had experience picking up a child, with 80% doing so rarely and 20% daily, while 100% confirmed they had never seen RFID applied in this context. This indicates that many schools in Malaysia still do not include this accessibility and technology.

Attendance tracking also relies heavily on paper registers or simple digital logs despite positive trials. For instance, the I-Attend system at a secondary school demonstrated high user satisfaction, scoring 4.71 out of 5 for ease of use, yet it remains an isolated case (Azri Mazlan & Ahmad, 2025). Similarly, the iHadir web-based RFID attendance platform showed promise in facilitating teacher-friendly automation but has had limited deployment (Mohamed Ali et al., 2021).

This limited implementation underscores a significant opportunity: integrating RFID technology into everyday school operations, such as pick-up authentication and attendance tracking, could modernise Malaysian educational systems. This study addresses this gap by proposing a cross-platform RFID solution to enhance student safety, improve administrative workflows, and give guardians real-time visibility during pick-up.

## **RELATED WORK**

Schools and parents are increasingly concerned about student safety, especially during arrival and pick-up. Institutions need solutions that ensure easy mobility and improved security because student numbers and traffic around schools are rising. To reduce manual labour and improve visibility of student movement, schools are gradually integrating technologies like RFID, IoT, and GPS.

Conventional pick-up arrangements mainly depend on manual sign-out procedures, visual recognition, or verbal confirmation. For guardians waiting outside school grounds, these approaches frequently cause delays, misunderstandings, and uncertainty. Without real-time information about a child's location or readiness, congestion worsens, and safety hazards rise. To reduce wait times and ensure kids are turned over safely, monitoring systems must provide prompt, accurate, automated updates.

Because they are easy to use, traditional monitoring methods for attendance and pick-up, like classroom registers, parent sign-out books, or student ID checks, are often used. However, they are vulnerable to human error and rely heavily on staff participation. These manual systems cannot support large-scale student management during peak hours or provide parents with real-time updates. Schools have therefore explored automated tracking methods to improve operational effectiveness and reliability.

Recent decades have seen the adoption of RFID, IoT sensors, GPS tracking, and mobile notifications to modernise school operations:

### **RFID-based School Bus Tracking System – ParentLink App**

This system issues RFID tags to students and installs RFID readers on school buses. Combined with GPS, it provides schools and parents with real-time bus locations, stop times, and student pick-up/drop-off records. Features include live tracking, accurate ETAs, two-way messaging, and attendance tracking via passive RFID student IDs integrated with GSM and the DriverLink App (WirelessLinks, n.d.).

### **IoT-based Smart Attendance System - SkoolSmart**

SkoolSmart offers an RFID-based tracking solution covering home-to-school-to-home travel, automatic attendance, and secure student handovers. Key features include RFID detection, SMS alerts for parents, on-board video monitoring, visitor photo capture, and route optimisation for transport efficiency. The system digitises entry/exit records and improves school safety (EdTechReview, 2016; SkoolSmart, n.d.).

### **Student Monitoring and Location Tracking System Using RFID**

This system assigns RFID tags to students and installs readers at key checkpoints such as hallways, cafeterias, and playgrounds. The system tracks movements in real time and displays them on a central platform, enhancing safety by enabling quick student location during emergencies and preventing unauthorised access (Kamble & Anjum, 2017).

Several patterns emerge across the reviewed systems: Transportation-oriented systems, such as ParentLink and SkoolSmart, offer efficient bus tracking capabilities; however, they lack support for on-campus pick-up procedures. Campus-only tracking systems are effective for indoor monitoring; however, they do not meet requirements for travel tracking and parent notification. Models that use only RFID technology are constrained by their reliance on fixed checkpoints and lack of real-time communication, limiting flexibility. IoT-integrated solutions demonstrate potential; however, they encounter challenges related to connectivity limitations, fragmented data flow, and insufficient guardian

engagement. Previous systems focus on isolated aspects of the student journey, such as bus travel or on-campus movement, and lack a comprehensive, integrated monitoring solution.

Previous studies show a notable lack of an integrated system that supports the full process of student arrival, movement, and pick-up readiness. Identified key problems include: No current solution provides comprehensive end-to-end tracking from home to school arrival, campus movement, and pick-up; insufficient real-time notifications for guardians, particularly at the precise moment a child is prepared for pick-up; the absence of digitalisation in the school pick-up process results in congestion, confusion, and inefficiencies; lastly, the absence of a role-based system that integrates RFID detection, scheduling, and notification restricts administrative efficiency.

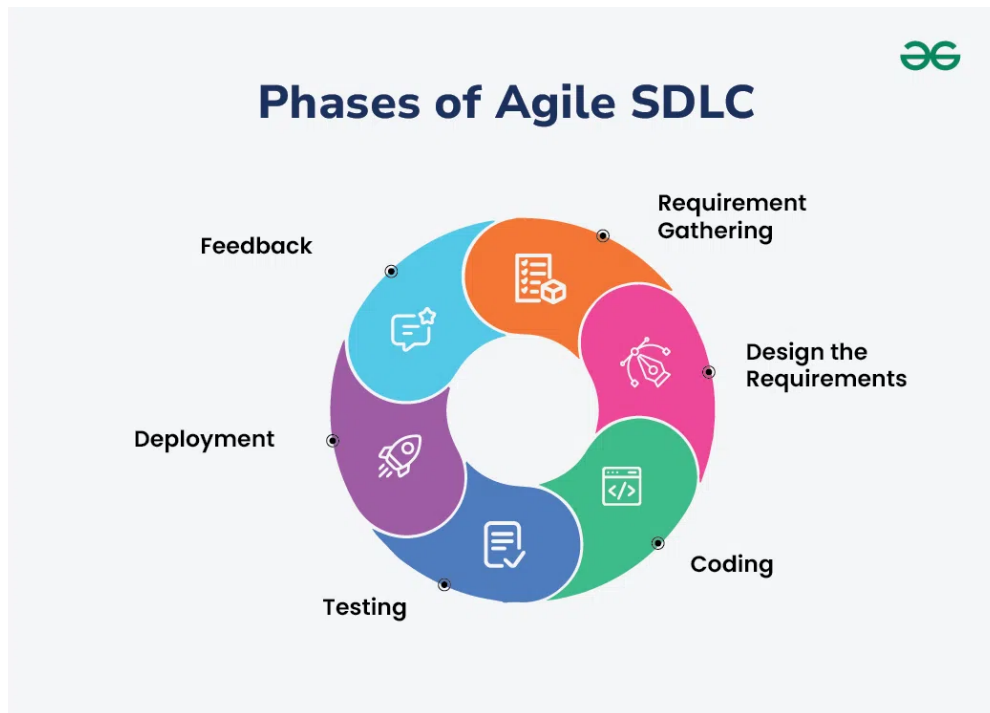
These limitations underscore the need for an integrated RFID- and IoT-based system for student arrival and pick-up detection. Such a system would automate attendance, enable real-time movement tracking, and provide timely notifications to guardians regarding their child's readiness for collection. This study presents a system that integrates RFID detection with real-time notifications, digital attendance, and scheduling modules to address these challenges.

## **METHODOLOGY**

The Student Arrival and Pick Up Detection System (SAPDS) uses an Agile methodology to ensure flexibility and adaptability throughout development. Agile methodology focuses on tractable development. This methodology divides a large module into several smaller, adaptive phases that are implemented iteratively (Patil et al., 2016). It is an incremental model that assesses each phase and guides the project, resulting in a shippable final product. Each stage includes planning, design, coding, testing, and user acceptance testing (IntroBooks Team, 2019). Agile is also the recommended development methodology for IoT projects such as SAPDS because it eliminates silos, gathers feedback quickly, tests early and often, and adapts to change (Wald, n.d.). Figure 1 illustrates the phases of the Agile methodology adopted in this study.

**Figure 1**

*Agile Methodology Phases*



*Note.* From *Agile SDLC (Software Development Life Cycle)*, by GeeksforGeeks, 2024 (<https://www.geeksforgeeks.org/software-engineering/agile-sdlc-software-development-life-cycle/>).

### **Phase 1: Planning**

The Planning Phase focused on defining the scope, goals, and deliverables of the RFID-based student pickup detection system. We translated key objectives into functional and non-functional requirements, such as selecting suitable RFID tags and readers to ensure accurate detection in crowded or open-air pickup zones. I gathered input from school administrators, teachers, parents, and technical staff to align the system with real needs, reflecting Agile's value of customer collaboration. The main outputs included a requirements specification, stakeholder feedback, a budget plan, a resource inventory, and a Gantt chart, providing a structured yet flexible foundation for development.

### **Phase 2: Design**

The Design Phase served as the system's blueprint, defining interactions between software and hardware components. Guided by Agile principles, the phase emphasised maintaining a clear vision while supporting iterative progress. Tools like Draw.io, StarUML, and Circuito.io were used to visually represent the database schema, prototype, and hardware layout, ensuring alignment between the development team and stakeholders.

### **Phase 3: Testing**

The Testing Phase of SAPDS ensured the system was accurate, reliable, and fast. Unit testing checked individual features like student registration, RFID detection, attendance logging, and notifications. Integration testing verified smooth data flow from RFID scanning to attendance recording and alerts. Performance testing confirmed the system could respond instantly, even during peak student arrivals and pickups.

#### **Phase 4: User Acceptance Testing (UAT)**

In the User Acceptance Testing (UAT) phase, five software engineers tested the system's functionality, usability, interface, flow, and performance. They assessed ease of use, navigation, and feature reliability to ensure it met user needs. Their feedback helped fix final issues and confirmed the system's readiness, aligning with Agile's focus on user feedback and improvement.

#### **Phase 5: Coding**

The system was designed as a cross-platform solution, accessible via web and mobile, using tools like Visual Studio Code, Arduino IDE, and Android Studio. Development relied on JavaScript, HTML, CSS, PHP, and services such as AWS EC2, RDS, and MySQL Workbench.

### **PROPOSED DESIGN**

Based on Figure 2, the database consists of four core tables: children, attendance, users, and timetable. The children table stores student details and RFID tag registration, while the attendance table logs scans with date, time, and status ("IN" or "OUT") for automated tracking. The users table manages system accounts with role-based access, ensuring security. Guardians provide additional details—such as the child's name, relationship, and car plate—to validate pickups and enhance safety. It also supports password reset via tokens and real-time push notifications for timely updates. Lastly, the timetable table stores subjects, time slots, and teacher assignments, enabling management of classes and teaching schedules. Figures 2, 3, and 4 show the database design, system prototype, and hardware diagram, respectively.

**Figure 2**

*Database Design*

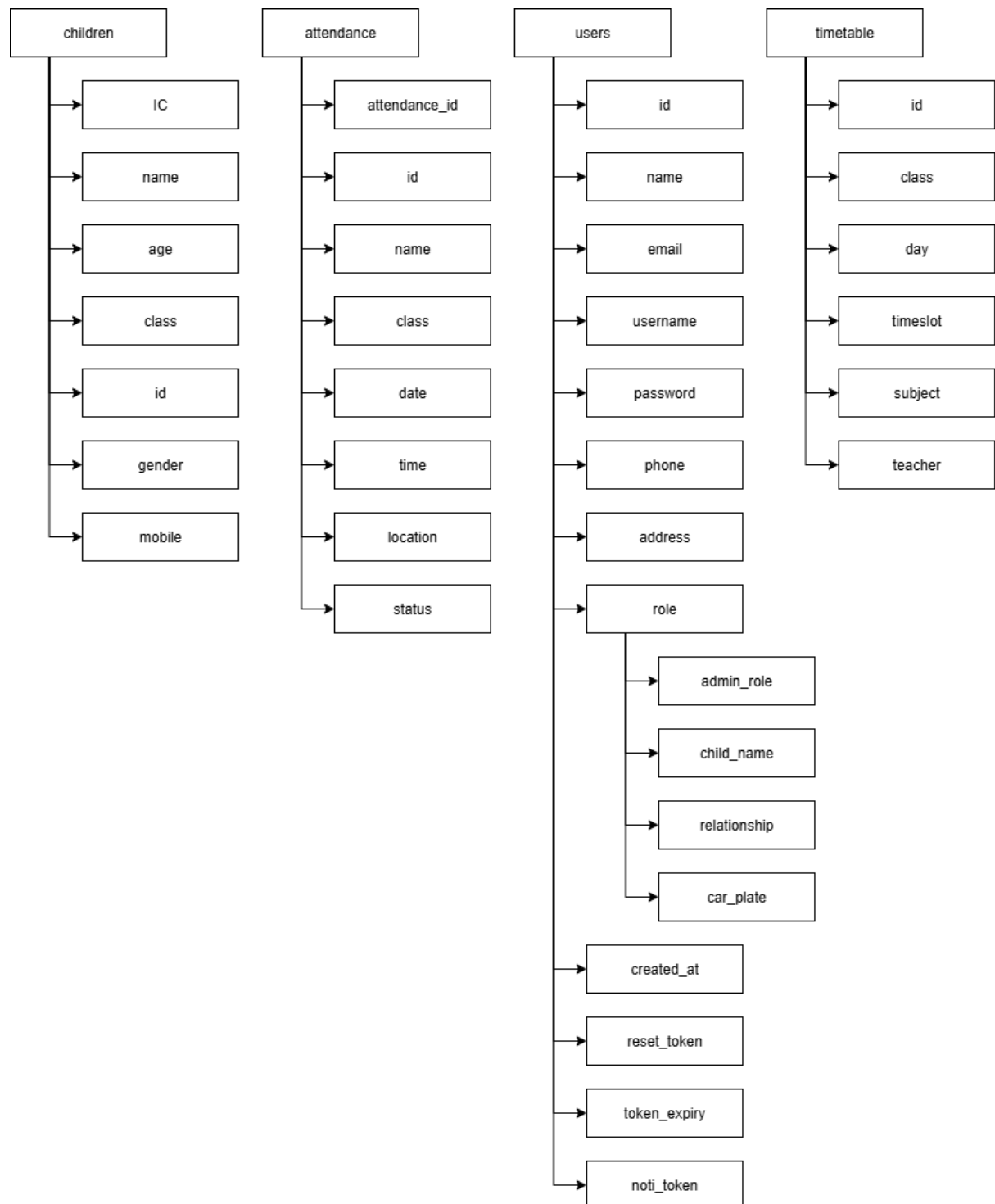
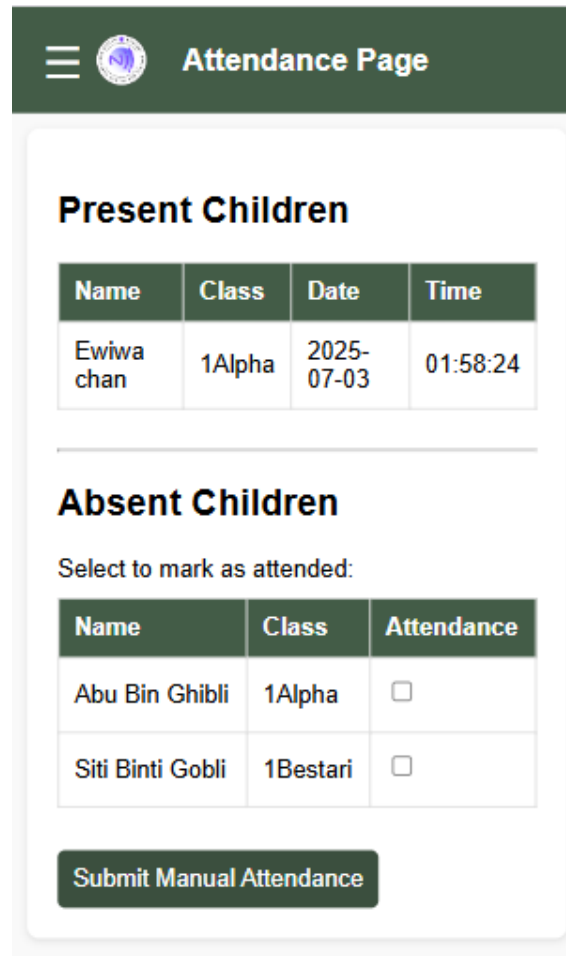


**Figure 3**

*System Prototype*



The image shows a mobile application prototype for an attendance system. At the top is a dark green header bar with a hamburger menu icon, a circular school logo, and the text "Attendance Page". Below the header, the page is divided into two main sections. The first section, titled "Present Children", contains a table with four columns: Name, Class, Date, and Time. It lists one child, Ewiwa chan, in class 1Alpha, with a date of 2025-07-03 and a time of 01:58:24. The second section, titled "Absent Children", includes a label "Select to mark as attended:" followed by a table with three columns: Name, Class, and Attendance. This table lists two children, Abu Bin Ghibli and Siti Binti Gobli, both in classes 1Alpha and 1Bestari respectively, with empty checkboxes in the Attendance column. At the bottom of the page is a dark green button labeled "Submit Manual Attendance".

| Name       | Class  | Date       | Time     |
|------------|--------|------------|----------|
| Ewiwa chan | 1Alpha | 2025-07-03 | 01:58:24 |

| Name             | Class    | Attendance               |
|------------------|----------|--------------------------|
| Abu Bin Ghibli   | 1Alpha   | <input type="checkbox"/> |
| Siti Binti Gobli | 1Bestari | <input type="checkbox"/> |

Submit Manual Attendance

Figure 3 shows the system's attendance page prototype, where school administrators can view attendance and add manual entries.

**Figure 4**

*Hardware Circuit Diagram*

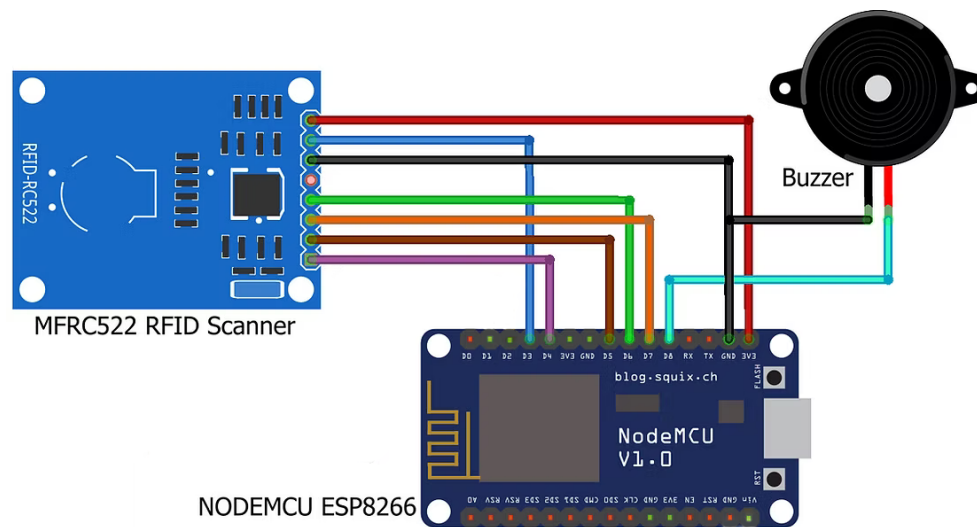


Figure 4 shows the circuit diagram between RC522, ESP8266 and the buzzer. Complete the circuit without damage, using the pin connections listed in Table 1.

**Table 1**

*Circuit Linkage Between RC522, ESP8266, and Buzzer*

| RC522 pin | ESP8266 pin | Buzzer pin |
|-----------|-------------|------------|
| 3.3V      | 3V          |            |
| RST       | D1          |            |
| GND       | G           | GND        |
| MISO      | D6          |            |
| MOSI      | D7          |            |
| SCK       | D5          |            |
| SDA       | D2          |            |
|           | D8          | Signal     |

*Note.* Blank cells indicate that the pin is not connected to that component.

In the Coding Phase, the RFID-based student pickup detection system was developed through iterative hardware and software integration. RFID readers and tags were programmed via Arduino IDE to detect student entries and exits, forming the system's core functionality, which `http.begin(client,"http://18.141.9.202/SAPDS/src/clerk/getUID.php");` and `http.addHeader("Content-Type", "application/x-www-form-urlencoded");` had transmitted the RFID ID back to the server. A real-time notification system using Firebase Cloud Messaging (FCM) alerts parents and staff instantly, while attendance is automated by logging each scan to the database. 'audience' => 'https://oauth2.googleapis.com/token' was added to retrieve the target receiver token and ensure the correct notification is sent to the correct user. Timetable management allowed clerks to assign subjects and teachers, with TCPDF enabling report exports in standardised PDF format using `$pdf = new TCPDF();`. Role-based access control ensured privacy by displaying `$row['role']` and restricting

guardians to their registered children, while a secure authentication system with PHPMailer supported account recovery using \$mail->SMTPSecure = PHPMailer::ENCRYPTION\_STARTTLS;.

## FINDING AND DISCUSSION

After the coding phase, the SAPDS was evaluated through functionality and usability testing. The evaluation was conducted at Sophic Automation Sdn Bhd., Juru, Penang, after working hours with prior permission. Five qualified software engineers with experience in RFID-based systems participated: three from Sophic Automation Sdn Bhd. (Software Engineer I and II), one frontend developer from IQI Global Holdings, and one equipment automation engineer from Infineon Technology (Kulim) Sdn Bhd. All participants, aged 21–30 with around two years of experience and involvement in at least three major projects, were deemed suitable for the evaluation.

Respondents tested the system using their preferred platform (web, mobile, or both), with RFID readers set up to simulate real use. Before testing, they received a briefing on the test cases to ensure consistency and reduce bias. The evaluation assessed functionality, usefulness, ease of use, performance, expectations, confirmation, satisfaction, continuance intention, and interface quality. A 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) captured user perceptions. Test cases and questionnaires are provided in Appendices 1–3. Table 2 shows the mean scores, while Figure 5 presents a bar chart for clearer comparison and analysis of user feedback.

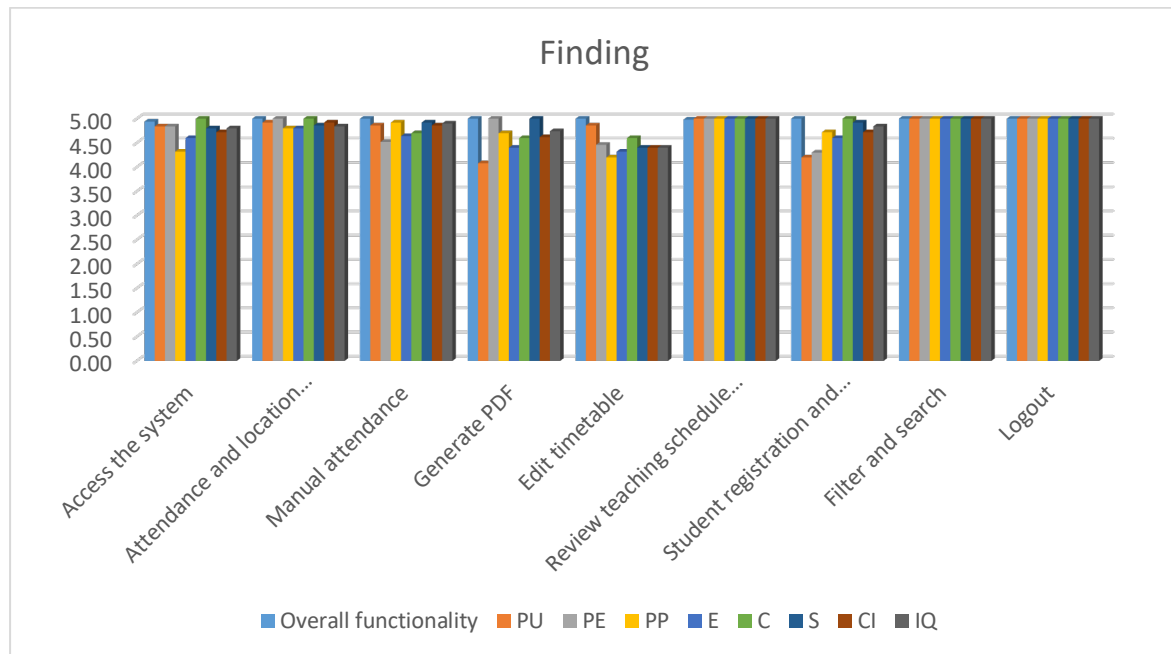
**Table 2**  
*Statistical Results of All Test Cases and All Aspects*

|                                  | Access<br>the<br>system | Attendance<br>and<br>location<br>logging | Manual<br>attendance | Generate<br>PDF | Edit<br>timetable | Review<br>teaching<br>schedule<br>and<br>class<br>timetable | Student<br>registration<br>and<br>manual<br>user<br>registration | Filter<br>and<br>search | Logout |
|----------------------------------|-------------------------|------------------------------------------|----------------------|-----------------|-------------------|-------------------------------------------------------------|------------------------------------------------------------------|-------------------------|--------|
| <b>Overall<br/>functionality</b> | 4.94                    | 5.00                                     | 5.00                 | 5.00            | 5.00              | 4.98                                                        | 5.00                                                             | 5.00                    | 5.00   |
| <b>PU</b>                        | 4.84                    | 4.92                                     | 4.86                 | 4.08            | 4.86              | 5.00                                                        | 4.20                                                             | 5.00                    | 5.00   |
| <b>PE</b>                        | 4.84                    | 5.00                                     | 4.52                 | 5.00            | 4.46              | 5.00                                                        | 4.30                                                             | 5.00                    | 5.00   |
| <b>PP</b>                        | 4.32                    | 4.80                                     | 4.92                 | 4.70            | 4.20              | 5.00                                                        | 4.72                                                             | 5.00                    | 5.00   |
| <b>E</b>                         | 4.60                    | 4.80                                     | 4.64                 | 4.40            | 4.32              | 5.00                                                        | 4.60                                                             | 5.00                    | 5.00   |
| <b>C</b>                         | 5.00                    | 5.00                                     | 4.70                 | 4.60            | 4.60              | 5.00                                                        | 5.00                                                             | 5.00                    | 5.00   |
| <b>S</b>                         | 4.80                    | 4.86                                     | 4.92                 | 5.00            | 4.40              | 5.00                                                        | 4.92                                                             | 5.00                    | 5.00   |
| <b>CI</b>                        | 4.72                    | 4.92                                     | 4.86                 | 4.62            | 4.40              | 5.00                                                        | 4.72                                                             | 5.00                    | 5.00   |
| <b>IQ</b>                        | 4.80                    | 4.84                                     | 4.90                 | 4.74            | 4.40              | 5.00                                                        | 4.84                                                             | 5.00                    | 5.00   |

*Note.* Values are mean scores on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). PU = perceived usefulness; PE = perceived ease of use; PP = perceived performance; E = expectation; C = confirmation; S = satisfaction; CI = continuance intention; IQ = interface quality.

**Figure 5**

*Findings of All Test Cases and All Aspects*



*Note.* Mean scores on a 5-point Likert scale. Abbreviations are defined in Table 2.

### Overall Functionality

The system achieved an excellent overall functionality score of 4.99 out of 5, indicating that its core features were implemented successfully and worked as intended. The score reflects ease of task completion, fulfilment of requirements, the absence of major bugs, and correct input handling, confirming the system's stability and readiness for deployment.

The only minor deduction came from the statement *"I am satisfied with the ease of completing this task,"* likely due to small usability issues such as unclear navigation or slightly complex workflows. While functionality was unaffected, these issues influenced users' perception of task ease. To address this, we will add features like tooltips and context-sensitive help to improve guidance and user flow.

### Perceived Usefulness (PU)

The system received a strong Perceived Usefulness score of 4.75 out of 5, indicating that users generally found it effective and beneficial for their tasks. The rating highlights the system's role in improving efficiency and achieving its intended goals, though the slight deduction suggests room for improvement.

Some respondents highlighted the need for more advanced reporting features to maximise its usefulness. For example, Yee Zhen Hong suggested that the PDF report should provide a more systematic summary of attendance rather than just raw data. This feedback is valid, as detailed insights would better support administrators' and parents' decision-making. Future improvements could include integrating analytics to summarise trends, punctuality, and anomalies, along with customizable reporting options to meet diverse user needs.

### **Perceived Ease of Use (PE)**

The system achieved a strong Perceived Ease of Use score of 4.79 out of 5, reflecting positive user experiences with its interface and functionality. This high rating suggests that users found the system straightforward and intuitive, with features that required minimal effort to operate. The design supported efficient task completion, reinforcing confidence in the system's overall usability.

However, certain areas revealed challenges that reduced the overall score. The main issue appeared in student and manual user registration. Users had to select either "Student" or "User" before accessing the registration form, and if they made no selection, the form remained blank. This design created confusion, leaving some unsure of how to proceed.

One participant, Neo Ming Ann, shared that *"I feel a bit miserable when I saw the display to be blank."* The lack of immediate guidance caused frustration and made the system feel unresponsive. Such issues highlight the importance of clear visual cues and feedback.

To improve usability, I recommend adding a default selection or dynamic form prompts. These changes would reduce uncertainty, simplify navigation, and enhance user satisfaction.

### **Perceived Performance (PP)**

The system received a strong Perceived Performance score of 4.74 out of 5, indicating respondents' satisfaction with the interface's visual design, layout, and responsiveness. Users found the system well structured, with logically arranged elements that supported efficient navigation and clear understanding of the content.

Despite the positive rating, respondents suggested minor improvements. One common recommendation was to move the password reset process inside the app rather than redirecting users to an external browser. This adjustment would ensure consistency, reduce friction, and prevent confusion, creating a seamless experience that maintains focus, builds trust, and improves the system's perceived performance.

### **Expectation (E)**

The system received an Expectation score of 4.7 out of 5, indicating that respondents generally found the interface consistent with their expectations. The design was considered intuitive, with elements placed in familiar positions that made the interface easy to navigate. This strong rating highlights the system's success in meeting user expectations and delivering predictable interactions.

Despite the positive feedback, the slight deduction points to opportunities for improvement. Respondents noted that the class timetable editing page felt cramped, with elements too close together. A more spacious layout with grouped fields or collapsible sections could enhance clarity and comfort.

### **Confirmation (C)**

The system achieved a strong Confirmation score of 4.87 out of 5, showing that respondents agreed the interface effectively supports their needs. This high score indicates users found the system reliable, practical, and well aligned with their daily tasks. The interface reinforced confidence in its ability to meet functional expectations and consistently support task completion.

The small deduction highlights areas for refinement. For instance, one respondent suggested adding a class-based filter when generating attendance PDFs. This improvement would save time by narrowing reports to specific classes, enhancing usability and making the system more efficient and user-friendly.

### **Satisfaction**

The system achieved a strong Satisfaction score of 4.87 out of 5, showing that respondents had a highly positive experience with the interface. This high rating suggests the system is both functional and enjoyable to use. Respondents appreciated the design and usability, indicating that the system successfully delivers a user-friendly experience that encourages continued engagement.

However, the editing timetable function scored slightly lower at 4.4, pointing to an area for improvement. Users noted that the layout felt too compact, with elements placed closely together. Increasing spacing, grouping related items, or adding collapsible sections could improve comfort and usability, making tasks easier and more intuitive.

### **Continuance Intention (CI)**

The system achieved a strong Continuance Intention score of 4.8 out of 5, showing that respondents are highly likely to keep using it and are generally satisfied with their experience. Users found the system pleasant, user-friendly, and reliable, reflecting its ability to build confidence and encourage consistent engagement over time.

However, the statement *"I would recommend it to a friend"* received the lowest score. This suggests that although users are satisfied, they may hesitate to recommend the system because of limited features, design constraints, or incomplete functionality. Enhancing usability, visual appeal, and customisation could strengthen satisfaction and encourage advocacy.

### **Interface Quality (IQ)**

The system achieved a strong Interface Quality score of 4.83 out of 5, reflecting respondents' highly positive perception of its visual and functional design. This high rating shows that the interface successfully meets expectations for aesthetics and usability. Users described it as clean, pleasant, and easy to navigate, supporting a smooth experience and minimising the learning curve. A well-designed interface also improves task efficiency and reduces the likelihood of user errors, which helps explain the overall favourable evaluation.

However, the editing timetable section scored slightly lower at 4.4 out of 5. Feedback noted that its compact layout made elements feel squeezed together, reducing readability and ease of interaction. This

indicates a need for improvement; a more spacious, structured design would enhance clarity and reduce cognitive load, especially for users managing detailed schedules.

## **CONCLUSION**

This study presented the development and evaluation of an RFID-based student management system focused on improving the school pick-up process. By equipping students with RFID tags and installing readers at school exit points, the system sends real-time notifications and location updates to guardians, ensuring they know exactly when their children are ready for pick-up. This reduces congestion, improves safety, and streamlines daily school operations. The developed prototype demonstrates the potential of RFID and digital technologies to modernise school environments in Malaysia. With further refinement and broader adoption, such systems could set a new standard for smart, connected, and safer schools.

To overcome the limitations of the Student Arrival and Pick-Up Detection System, future work will improve the system's functionality and usability. First, increase the RFID scanning range to ensure the system records students' location and attendance even if they do not tap their RFID tag on the reader. This can be completed by integrating passive ultrahigh-frequency (UHF) RFID transponders. Second, to address respondents' comments, the system interface and functionality will be improved by simplifying timetable editing, adding a user manual or tutorials, and more. Finally, the system will be integrated into schools to identify and address real-world problems.

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