

# Waves of Security: RFID-Enabled System and Attendance Monitoring of Students

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## Index Terms:

radio frequency identification (RFID), automated attendance system, smart identification technology, student tracking system, campus security management, digital monitoring, educational information systems, school-based automation, data management, technology integration

**Abstract.** A radio frequency identification (RFID) ID system is a method of identifying people using radio waves. It detects and records individuals through tags embedded in their ID cards. An automated attendance system is a digital tool that tracks and manages student attendance without needing manual input. This greatly improves accuracy, reliability, and overall efficiency while lowering human errors and administrative burdens. This study used a quasi-experimental quantitative design to assess the effectiveness of the RFID-enabled attendance system with SMS notification features for monitoring student attendance at Maguikay National High School in Mandaue City. The researchers conducted descriptive statistical analysis to evaluate the system's performance, reliability, and efficiency during the trials throughout the study. The results showed that the RFID system consistently recorded attendance accurately and reliably across all trials. It demonstrated its ability to efficiently monitor attendance. However, the performance of the SMS notification feature varied based on network conditions, signal strength, and system load during different testing periods. The system aimed to provide a quicker, more organized, and user-friendly way to track student entry and exit at school, all while keeping precise attendance records. The SMS notification feature was designed to improve communication between the school and parents or guardians by sending timely alerts about student attendance status. This promotes transparency and parental involvement. Overall, the findings confirm that the RFID-enabled attendance system is a reliable, efficient, and effective tool for enhancing attendance monitoring. It supports administrative processes and may benefit various educational institutions looking to implement technology-based solutions for managing students.

## Introduction

Radio frequency identification (RFID)-enabled identification system utilizes radio waves to detect and record the presence of individuals through embedded tags in identification cards. In educational institutions, this technology enables automatic student check-in by requiring only a tap of the identification card on an RFID reader, thereby enhancing the efficiency and security of access monitoring. According to Ishaq and Bibi (2023), RFID systems in educational settings facilitate real-time attendance logging, minimize manual effort, and increase data accuracy by integrating smart cards with automated detection tools. These features offer institutions a more rapid and dependable method for managing student movement and verifying identities. An automated attendance system is a digital tool that uses technology to record and manage students' attendance without the need for manual input. It helps ensure that students actually attend class, improving their safety and accountability in school. According to Ahmed (2021), it is an educational Enterprise Resource Planning (ERP) system designed to record students' attendance in an institution. Unlike conventional methods, this system

allows faculty to automatically record, store, and monitor attendance history, making classroom management more efficient. Recent data from Global Growth Insights (2024) estimates the global market for student RFID tracking systems at USD 952.6 million, with projections reaching USD 1.01 billion by 2025. This consistent growth reflects a global shift toward more reliable and technology-driven attendance systems in schools. RFID technology has become increasingly valued for its ability to automate attendance, enhance student security, and minimize administrative workload. In the Philippine context, early implementations have shown encouraging results. One such case is Project R.E.A.D.Y., an RFID attendance system deployed in a public senior high school in Rizal. The system was assessed by 200 students and parents, as well as 30 educators and staff. Findings showed that (57.5%) reported increased safety, (55%) highlighted improved data efficiency, and (52.5%) expressed satisfaction with the system's functionality (Agdong et al., 2022). These figures suggest that RFID-enabled attendance systems, especially when integrated with features like SMS notifications to parents, can provide a practical and effective solution for improving school monitoring, accountability, and communication.

Internationally, Bhingarde and Parulekar (2018) conducted a study titled "*RFID-Based Automatic Student Attendance and Parent SMS Notification System*," published in Rajkot, Gujarat, India, through the *International Journal of Scientific Research in Science and Technology (IJSRST)*. The study states that implementing an RFID-based automatic attendance system with SMS notifications provides a more accurate and efficient alternative to traditional manual methods. By integrating RFID technology with a .NET application and database, attendance is automatically recorded, and real-time alerts are sent to parents when students are absent. This system not only improves record-keeping but also enhances transparency and strengthens communication between schools and parents.

Nationally, Biag (2021) conducted a study titled "Electronic Cartero Machine (ECM): An RFID-Based One-Way SMS-Sending Kiosk," presented in Tarlac City, Philippines, states that the Electronic Cartero Machine (ECM) is a practical and efficient solution for one-way communication between students and parents using RFID technology. It effectively leverages the school's existing RFID system, allowing students to send messages by simply tapping their ID cards. The system received excellent user feedback on appearance, ease of use, and maintainability, demonstrating that it is user-friendly and easy to operate. It also performs comparably to regular mobile phones in message sending speed. The study concludes that the ECM is a reliable and acceptable tool for enhancing school-to-home communication.

Locally, Flores (2021) conducted a study titled "Classroom Attendance Monitoring System Using Radio Frequency Identification with Web Application," from the University of San Carlos, Cebu, Philippines, states that the system accurately tracks attendance using RFID and motion sensors. The RFID module detected tags within 3 meters, and the motion sensors responded within 16 seconds. The hardware successfully identified tags, detected direction, validated data, and showed results. The web application allowed users to log in, view attendance, and manage class records. Faculty could also edit attendance and generate seat plans. The study shows that the system is reliable, efficient, and easy to use for automating classroom attendance.

Based on the attendance statistics the researchers compiled, grade 7 students consistently record the lowest attendance rates among grade levels, with an average of only 91% in the first quarter (June–August), while Grades 8 to 12 maintained higher averages ranging from 96% to 98%. This significant gap indicates that newly transitioned grade 7 learners struggled more with consistent school attendance, possibly due to adjustment challenges in a new environment. Therefore, this study focused on monitoring grade 7 students' attendance using an RFID-enabled ID system with SMS notification features, aiming to address their lower attendance rates and improve communication between the school and parents, rather than focusing on higher grade levels where attendance rates are already more stable.

This study examined the use of an ID system with RFID technology and SMS notification features in public high schools. The primary objective was to evaluate the system's functionality, effectiveness, and reliability in enhancing student attendance monitoring, strengthening school security, and improving communication between schools and parents.

### *Theoretical Background*

This study is anchored in Sustainable Development Goal 9 (SDG 9 Theory), established by the United Nations in 2015. It is supported by Socio-Technical Systems (STS) Theory by Eric Trist and Fred Emery (1981).

The Sustainable Development Goals (SDGs) constitute a global initiative comprising 17 objectives that address sustainability, innovation, and other critical challenges. SDG 9 identifies innovation as a key driver for improving systems and services. It promotes the adoption of modern technologies to resolve practical issues, such as attendance monitoring and school communication. Integrating RFID systems with SMS alerts aligns with this objective by providing an innovative approach to tracking student attendance and delivering real-time notifications to parents.

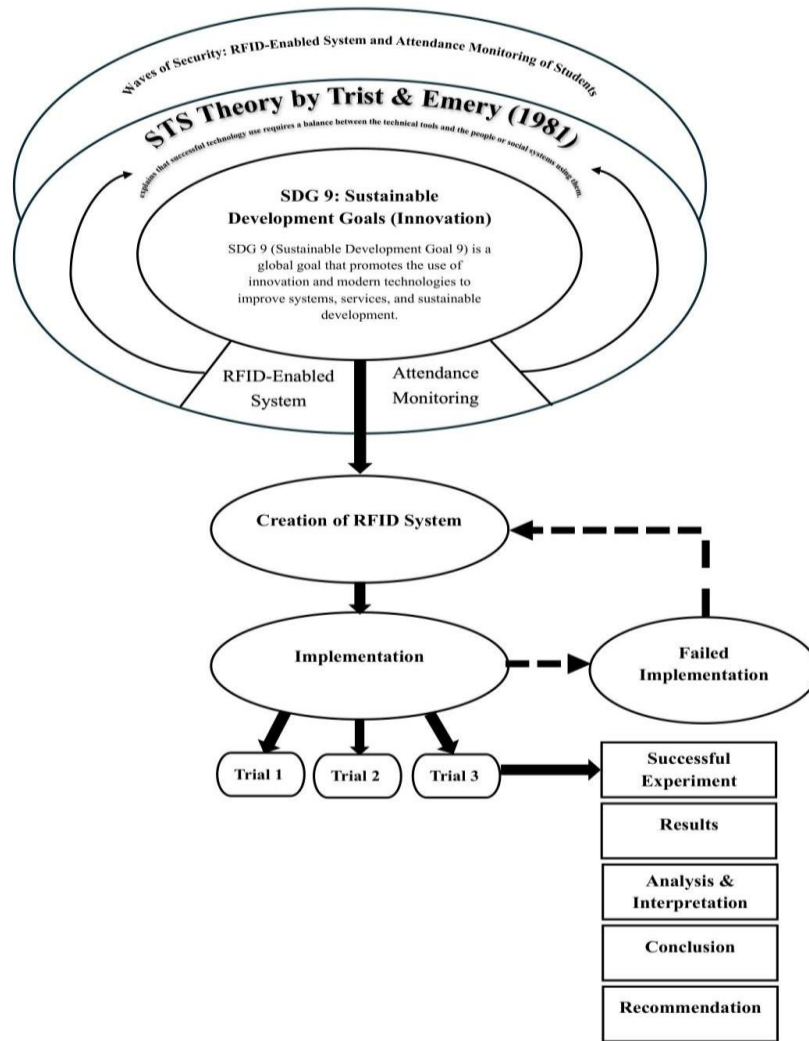


Figure 1. Schematic diagram of an RFID-based system for student attendance monitoring

This integration reduces uncertainty, strengthens collaboration between schools and families, and modernizes attendance procedures. As a result, schools can enhance operational efficiency and communication through digital innovation.

The SDG 9 framework, emphasizing innovation, is relevant to this study because it highlights the importance of integrating innovative solutions that promote sustainability and operational improvement. Implementing an RFID system aligns with SDG 9 by offering a modern approach to more accurate and efficient attendance monitoring. This system reduces manual processes, enhances data collection, and strengthens overall school operations. Through innovation, schools can implement advanced solutions that support long-term development goals. This alignment with SDG 9 illustrates how technological integration in education can drive meaningful and sustainable progress (United Nations, 2015).

By applying the SDG 9 framework focused on innovation, this study demonstrates how technological advancements can improve the performance of school attendance systems. The RFID system enhances attendance accuracy by automatically recording student data and increases efficiency by reducing manual processes and preserving instructional time. Reliability is further ensured through digital records and immediate notifications to parents, which promote transparency. The focus on innovation in SDG 9 underlies these improvements and supports lasting benefits for both schools and the wider community.

This study is also informed by Socio-Technical Systems (STS) Theory, developed by Eric Trist and Fred Emery (1981). STS Theory asserts that effective technological implementation within organizations requires a balance between the technical

system, which includes tools, devices, and software, and the social system, comprising users, their skills, habits, and interactions. Without alignment between these systems, even advanced technologies may not achieve optimal performance. For instance, Geary et al. (2022) reported that applying STS in a hospital setting with RFID technology did not improve workflows when staff lacked training and processes were not adapted. This finding highlights the necessity for both technological and human factors to function collaboratively. The theory maintains that introducing new technology alone is inadequate; users must also be equipped to adapt through proper training, effective communication, and modifications to routines. When technical and social systems are mutually supportive, technology adoption is more effective and sustainable. The RFID-enabled system illustrates this principle, as it requires both dependable tools and user readiness. A balanced approach ensures the long-term sustainability of RFID technology. Therefore, the theory reinforces the necessity of integrating technological innovation with human and organizational processes.

Socio-Technical Systems Theory is relevant to this study because it clarifies how RFID-enabled ID systems and automated attendance monitoring can improve accuracy, efficiency, and reliability. Accurate attendance records depend on students consistently scanning their RFID cards. Efficiency is measured by the speed of attendance recording without disrupting instructional time. Reliability depends on the system's consistent operation and users' competence. These factors are consistent with the STS approach, which supports the effective integration of technology within social contexts such as schools. In summary, the integration of STS and SDG 9 provides a comprehensive framework for evaluating and enhancing the implementation of RFID-enabled systems. STS focuses on aligning technology with the social needs of the school, while SDG 9 underscores the importance of addressing these needs through innovation. Together, these frameworks encourage the development of systems that are efficient, interactive, and adaptable to future requirements. This approach enables schools to improve the sophistication and reliability of attendance monitoring, establishing innovation as a key factor in school improvement and parental engagement.

### *Statement of the Problem*

This research examined the effectiveness of the RFID-enabled ID system and automated student attendance monitoring at Maguikay High School during S.Y. 2025–2026. The results of the study served as the basis for future improvements and recommendations.

Specifically, this study addressed the following questions:

1. How accurate is the RFID-enabled ID system in recording student attendance in terms of:
  - 1.1 entry during school time;
  - 1.2 sms delivery to parents/guardians; and
  - 1.3 exit after school time?
2. How efficient is the automated attendance monitoring system in terms of:
  - 2.1 time difference;
  - 2.2 number of errors or missed scans; and
  - 2.3 system responsiveness during peak hours?
3. How reliable is the RFID attendance system in terms of:
  - 3.1 how system works without problems;
  - 3.2 how system can work before needing repairs; and
  - 3.3 students' attendance data is saved safely and can be checked anytime?
4. Based on the results, what recommendations may be proposed?

### *Statement of the Hypotheses*

H0: The RFID-enabled ID system and automated attendance monitoring will not significantly improve the efficiency of student attendance tracking.

H1: The RFID-enabled ID system and automated attendance monitoring will significantly improve the efficiency of student attendance tracking.

## **Methodology**

### *Research Design*

This study used a quasi-experimental design to assess the effectiveness of an RFID-enabled attendance system with SMS alerts for monitoring student attendance. The purpose was to assess the relationship between the RFID system and attendance monitoring performance. According to Creswell and Creswell (2017), quasi-experimental designs are

appropriate when researchers aim to examine causal relationships but cannot randomly assign participants to groups. In this study, the RFID system served as the independent variable, while attendance accuracy, system efficiency, and reliability served as the dependent variables.

A quasi-experimental design was used to generate valid and meaningful results in a real school setting. Rogers and Revesz (2019) explain that quasi-experimental designs are commonly used in educational research, where intact groups are employed and random assignment is not feasible. Since this study involved existing grade 7 students, the design allowed researchers to examine the effect of the RFID system on attendance monitoring performance without disrupting the natural classroom structure.

During implementation, the researchers evaluate the system's effectiveness through three key dimensions: accuracy (successful scans for entry, late, and exit), efficiency (time taken to log attendance and responsiveness during peak check-in hours), and reliability (consistent data storage, minimal system errors, and successful SMS delivery). Structured data collection tools were used to record these outcomes in the school environment, enabling measurable observation of changes after introducing the RFID system.

The quasi-experimental design was essential in testing the study's hypotheses because it enables evaluation of an educational technology intervention under real-world conditions. By focusing on measurable outcomes such as accuracy, efficiency, and reliability, the approach ensures that the collected data are valid and applicable to public educational institutions. The findings provided a basis for future improvements and wider adoption of RFID-based attendance monitoring systems.

#### *Research Participants*

The research participants of this study were selected grade 7 students from Maguikay National High School. The grade 7 was chosen as the focus of the study because it had the lowest attendance rate among the grade levels, making it the most appropriate group for evaluating the effectiveness of the RFID enabled ID system in improving attendance monitoring. By involving students who commonly experience attendance concerns, the researchers were able to assess how the system performs in addressing real and existing attendance challenges within the school.

#### *Sampling Technique*

This study utilized a purposive sampling technique, a non-probability sampling method in which participants are deliberately selected based on specific characteristics relevant to the research objective. The researchers purposely chose grade 7 students with lower attendance performance, which aligns with the aim of evaluating improvements in attendance monitoring. The selection was not done randomly; instead, participants were identified and invited based on their suitability for the study.

Specifically, five (5) students were selected from each of the four (4) grade 7 sections, resulting in a total of twenty (20) participants. The researchers personally approached the selected students and asked them to participate in the study. This method ensured that the participants were directly relevant to the research problem and enabled the researchers to gather focused, meaningful data on the effectiveness, efficiency, and reliability of the RFID attendance monitoring system.

#### *Research Environment*

This experimental research was conducted at Maguikay High School, Mandaue City. The experimentation involved deploying the RFID-Enabled ID System and Automated Attendance Monitoring in a controlled school environment to test their performance and effectiveness. The system was applied during actual school operations to observe how it monitored student attendance in real time. Data collection focused on measuring attendance accuracy, efficiency, and operational reliability. The gathered data was then analyzed to evaluate the system's impact on the reliability of its attendance monitoring.

#### *Research Materials and Equipment*

The study utilized several hardware components for the development and implementation of the RFID-based attendance monitoring system with SMS notification. The materials included twenty MIFARE 1KB RFID cards used to store unique student identification data, which were scanned by the RFID reader to record student attendance. An Arduino Uno microcontroller served as the main controller of the system, receiving and processing the scanned RFID card information. An RC522 module was used to detect and read the RFID cards, allowing the system to identify users and perform specific actions. An 830 tie-points breadboard and female-to-male jumper cables were used to connect the Arduino, RC522 module,

and other components without soldering, enabling easy circuit prototyping and testing. A USB cable was used to supply power to the Arduino Uno and upload the program from the computer. A SIM800L V2 5V Wireless GSM GPRS module, together with a TNT SIM card, was used to send SMS notifications to parents whenever a student recorded a time-in or time-out. A laptop was used to program the Arduino, manage the RFID data, and monitor the system in real time. Lastly, a transparent box was used to house and protect the hardware components from dust and physical damage while allowing easy access for maintenance and observation.

#### *Software / Applications*

The study also utilized several software applications for programming, data processing, and database management. The **Arduino IDE** was used to write, edit, and upload the program to the Arduino Uno, allowing the system to control the RFID reader, process student attendance, and trigger SMS notifications. The **XAMPP Control Panel** was used to run a local server and manage the system's database, enabling the storage, viewing, and management of student attendance records. In addition, **Python** was used to process attendance data, automate communication between the Arduino system and the database, and support the management of SMS notifications sent to parents or guardians. These software applications ensured the proper operation, monitoring, and data handling of the RFID-based attendance monitoring system.

#### *Cost Estimation*

The study required several materials and electronic components for the development of the RFID-based attendance monitoring system with SMS notification. The researchers purchased twenty RFID ID cards costing ₱170 to serve as student identification tags for attendance scanning. An Arduino kit worth ₱1,499 was also used, which included essential components such as the Arduino UNO R3, RC522 RFID reader, breadboard, jumper wires, sensors, LEDs, resistors, buzzers, motors, and other electronic modules needed for system assembly and testing. In addition, a SIM800L V2 5V Wireless GSM GPRS module costing ₱355 was used to enable SMS communication between the system and the parents or guardians. To support SMS notifications, three prepaid mobile loads (SAYA ALL 99) with a total cost of ₱297 were used for network connectivity. These materials and components were necessary for building, operating, and testing the RFID attendance monitoring system with SMS notification.

#### *Research Procedure*

##### *Safety Preparations*

In research, safety preparation refers to the planning and implementation of measures to prevent accidents, injuries, and hazards before commencing experiments or data collection. Accordingly, the researchers ensured a safe process in creating the RFID-enabled system, taking precautions to prevent any accidents or injuries to the researchers.

- Ensure all electrical components were in good condition (no exposed wires).
- Work in a dry, well-ventilated area to avoid damage to components and ensured safety.
- Wear appropriate safety gear (e.g., gloves when handling electronics).
- Keep liquids away from the setup to prevent short circuits.
- Ensure the Arduino is powered off before connecting or disconnecting components.

##### *Hardware / Physical Materials:*

- 20 pcs MIFARE 1KB RFID cards
- 1 pc Arduino Uno
- 1 pc RC522 RFID Module
- 1 pc 830 tie-points breadboard
- 10 pcs Female-Male jumper wires
- 1 pc USB cable for Arduino Uno
- 1 pc Laptop
- 1 pc SIM800L V2 5V Wireless GSM GPRS Module Blue
- 1 pc Transparent Box
- 1 pc TNT SIM
- Load, 3 recharges
- *Software / Applications:*
- 1 installed Arduino IDE
- 1 installed XAMPP Control Panel
- 1 installed Python

Step by step process

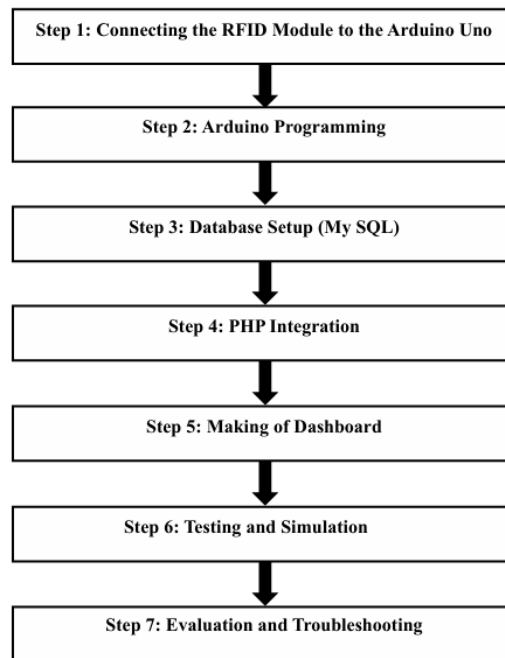


Figure 2: Schematic representation of the step-by-Step Process of the RFID system

#### Step 1: Hardware Setup

The system was built using three main components: an Arduino Uno, an RFID card reader, and a SIM800L GSM module. The RFID reader detected student ID cards when tapped, while the GSM module sends text messages through the mobile network to notify parents or administrators about attendance.

##### RFID RC522 → Arduino Uno

- SDA → Pin 10
- SCK → Pin 13
- MOSI → Pin 11
- MISO → Pin 12
- RST → Pin 9
- 3.3V → 3.3V
- GND → GND

##### SIM800L GSM → Arduino Uno

- TX → Pin 7
- RX → Pin 8
- VCC → 5V
- GND → GND

#### Step 2: Arduino Code

- Installed MFRC522 and SPI libraries for RFID.
- Used SoftwareSerial for SIM800L.
- Detecting RFID card UID.
- Matched UID with student database (stored locally or via server).
- Send SMS using commands.
- Send UID + timestamp to server.

*Step 3: Database Setup (MySQL)*

- Created a table to store student information (ID, LRN, Name, Grade, Section, Photo, UID and Parent's Phone Number).
- Created another table to store attendance records ( ID, LRN, time in, time out ).
- Saved each student's RFID UID in the student table.
- When a card is scanned, the Arduino sends the code to the server.
- The server automatically saves the attendance record into the database.

*Step 4: PHP Integration*

- Connected the Arduino to a PHP program that receives the card code.
- The PHP program checks the card code against the student list in the database.
- Once the student is identified, the program retrieves their information.
- The program then records the attendance in the attendance table.
- This process happens automatically every time a card is scanned.

*Step 5: Dashboard*

- Build a web-based dashboard
- Add a secure login page for authorized access.
- Included a photo view so that when students tap their card, their photo will appear on the dashboard.
- Display attendance records in a table showing student name, LRN, Section, Date, time in, time out and status.
- Included search and filter options to view records by date or student.

*Step 6: Testing and Simulation*

- Multiple RFID cards were scanned to simulate student attendance.
- Each scan was verified by checking three outputs:
- The card code appeared in the Python program (reading data from Arduino).
- A text message was sent through the GSM module.
- Attendance was logged in the database and displayed on the dashboard.

*Step 7: Evaluation and Troubleshooting*

- Issues such as unstable power supply for the GSM module, weak mobile signal, or duplicate database entries were identified and corrected.
- The dashboard was optimized to ensure fast and accurate display of records.
- The system was refined to guarantee consistent performance during repeated use

*System Operational Flow*

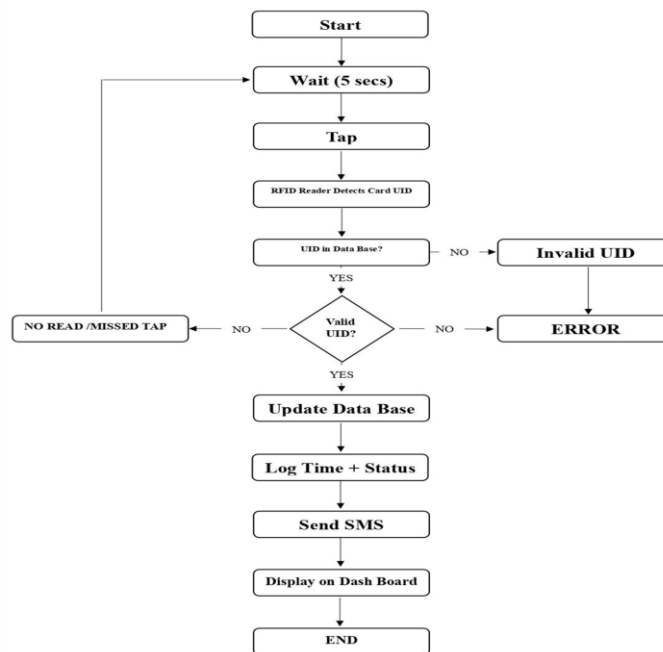


Figure 3: Schematic Representation of the System Flow of the RFID Attendance Monitoring System

### Execution and review of Trials

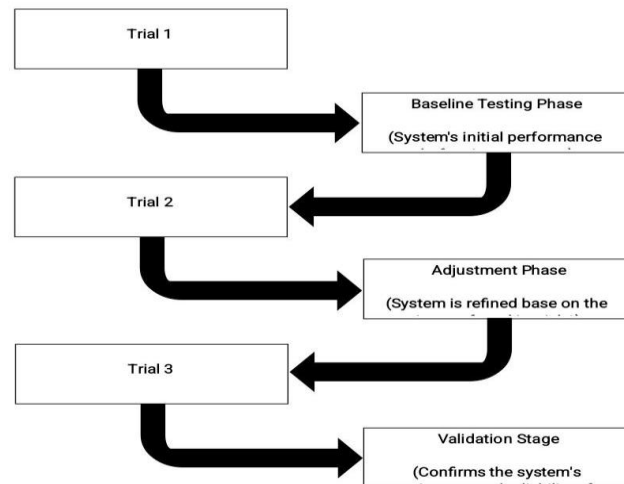


Figure 4: Schematic diagram of the Sequential Execution and Evaluation of System Trials.

Trial 1 served as the baseline testing phase, where the RFID-enabled attendance monitoring system was installed at the school's main entry point of Maguikay High School and was configured to log attendance data in real time. Twenty Grade 7 participants were issued RFID cards and were given a short orientation on how to properly scan upon entry, late arrival, and exit. The system was tested for one school week under normal operating conditions, with each scan automatically recorded in the database and followed by an SMS notification to the designated parent or guardian. Manual roll calls were conducted in selected sessions to compare results with the RFID logs. The focus of this trial will be to establish baseline data on system accuracy, scanning time, and SMS delivery performance. Any missed scans, delayed notifications, or technical errors were recorded and analyzed to identify areas for improvement in the next phase.

Trial 2 functioned as the adjustment phase. Improvements were made based on the findings from Trial 1, such as repositioning the RFID reader for better accessibility, refining the system code for faster database processing, and reinforcing student instructions. The trial was conducted for another full week, with special attention given to "peak times," defined in this study as moments when most or all of the 20 participants will scan their IDs within a short time frame, such as during morning arrival or dismissal. This setup allowed the researchers to observe the system's responsiveness and accuracy under higher scanning frequency. Data collection during this phase included scan success rate during peak and off-peak times, average scanning duration, queue time, and SMS delivery speed. Any performance gaps identified were addressed before moving to the final phase.

Trial 3 will serve as the validation stage to confirm the repeatability and reliability of the system under optimized conditions. The best-performing configuration from Trial 2 was retained, and the system was tested over two consecutive weeks. In addition to regular attendance monitoring, controlled stress tests were conducted, such as briefly simulating a network outage to assess the system's ability to log data offline and sync once connectivity was restored. Backup and restore procedures were also tested to ensure the safety of attendance records. Accuracy rates, SMS delivery performance, and system stability were closely monitored, and results were compared with manual roll calls. The findings from Trial 3 provided the final evaluation of the system's readiness for full-scale implementation, as well as recommendations for sustaining its accuracy, efficiency, and reliability in the long term.

#### Data Gathering

#### Positive Control

The researchers assessed the performance of RFID-enabled systems by testing its efficiency, reliability, and accuracy in recording the attendance of the students. This will allow the researcher to determine the system's effectiveness in streamlining the attendance process and ensuring accurate record-keeping.

*Formulation of the Experimental Setup*

The researchers conducted the creation of the product in Maguikay National Highschool, Mandaue City. The materials were gathered by canvassing different electronic shops and online shops.

*Statistical Treatment*

This study employed hypothesis testing as the primary statistical method. According to Ramdas and Wang (2024), hypothesis testing is a formal procedure for evaluating assumptions about a population parameter by analyzing sample data. It involves stating a null hypothesis(H0) representing no effect or no difference, and an alternative hypothesis (Ha) representing the presence of an effect or difference. In this study, hypothesis testing was used to assess whether the mean performance measures of the developed RFID system — including mean scan time, mean queue time, and mean SMS notification delay — significantly differ from the benchmark values claimed by Impinj RFID technology company. The process involved setting the significance level ( $\alpha=0.05$ ), computing the appropriate test statistic from the sample data, and comparing the result to the critical value or p-value to determine whether to reject or fail to reject.

**Results and Discussion**

*The accuracy of the RFID-enabled ID system in recording student attendance.*

The experiment utilized an RFID-enabled system to monitor student attendance. The system was installed at the main entry point of Maguikay High School and configured to record attendance data in real time. The experimental procedure consisted of three trials: Trial 1 (Baseline Testing Phase), Trial 2 (Adjustment Phase), and Trial 3 (Validation Phase). These trials were conducted to evaluate the system's performance before adjustments, after system optimization, and during final validation.

	<b>Week 1</b>				
	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
<b>Entry Level</b>	100.00%	100.00%	100.00%	100.00%	0.00%
<b>SMS Delivery</b>	50.00%	43.75%	69.23%	0%	0.00%
<b>Exit Level</b>	100.00%	100.00%	100.00%	100.00%	100,00%
<b>SMS Delivery</b>	62.50%	37.50%	86.67%	76.47%.	0.00%

*Table 4. Baseline Testing Phase*

Table 4 presents the data gathered during the baseline testing phase of the RFID-enabled attendance monitoring system. The table shows the system's initial performance in recording student entry and exit, along with the corresponding SMS notifications sent to parents or guardians. Table 4 shows the baseline performance of the RFID-enabled ID system at

	<b>Week 2</b>				
	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
<b>Entry Level</b>	100.00%	100.00%	100.00%	100.00%	0.00%
<b>SMS Delivery</b>	0.00%	75.00%	88.89%	0.00%	0.00%
<b>Exit Level</b>	100.00%	100.00%	100.00%	100.00%	0.00%
<b>SMS Delivery</b>	94.74%	87.50%	81.25%	64.71%	0.00%

*Table 5. Adjustment Phase*

Table 5 presents data from the adjustment phase of the RFID-enabled attendance monitoring system, showing performance after technical modifications aimed at improving accuracy, efficiency, and reliability. During Trial 2 at Maguikay High School, RFID scanning for both entry and exit maintained 100% accuracy from Day 6 to Day 9, demonstrating reliable attendance recording. On Day 10, accuracy dropped to 0% because the student was in the Alternative Delivery Mode (ADM) and did not physically attend, not due to system failure. SMS notification delivery improved compared to the baseline. Exit-level SMS success reached 94.74% on Day 6 and remained above 80% until Day 8, while entry-level SMS peaked at 88.89% on Day 8. However, entry SMS dropped to 0% on Days 6, 9, and 10, indicating occasional delays or failures. These variations show that while RFID reliably records attendance, SMS efficiency depends on factors such as signal strength, network congestion, and environmental interference. Trial 2 demonstrates that RFID consistently captured attendance with high accuracy, while SMS notifications remained variable. RFID reliability stems from its operation in a short-range, controlled environment, whereas SMS relies on external GSM networks vulnerable to fluctuations, congestion, and interference, which can cause delays or failures (Alsharif & Nordin, 2017). Older mobile networks further exhibit inconsistent latency during peak usage, underscoring the need for stable network conditions for real-time messaging (Sauter, 2018). Overall, the RFID subsystem is dependable for attendance recording, while SMS performance highlights its reliance on network infrastructure for timely delivery.

Week 3					
	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
<b>Entry Level</b>	100.00%	100.00%	100.00%	100.00%	100.00%
<b>SMS Delivery</b>	66.67%	62.50%	65.43%	66.67%	88.89%
<b>Exit Level</b>	100.00%	100.00%	100.00%	100.00%	100.00%
<b>SMS Delivery</b>	66.67%	55.00%	90.0%	90.00%	93.75%

Table 6. Validation Phase

Table 6 presents data from the validation phase of the RFID-enabled attendance monitoring system, showing its final performance after adjustments and confirming accuracy, efficiency, and reliability under actual conditions. During Trial 3, RFID scanning for both entry and exit maintained perfect accuracy (100%) from Day 1 to Day 5, demonstrating consistent and reliable detection of student taps. In contrast, SMS delivery varied across the five days. Entry SMS success ranged from 62.50% on Day 2 to 88.89% on Day 5, while exit SMS delivery fluctuated more, from 55.00% on Day 2 to 93.75% on Day 5. These variations indicate that, while RFID achieved maximum reliability, SMS performance depended on external network conditions. Using a 2G communication network, message delivery is affected by signal strength, congestion, and environmental interference, which can cause delays even when RFID and database components function correctly. Research shows 2G GSM systems have limited signaling and control capacity, affecting time-sensitive communication such as SMS (Kheddar, 2022), and weak signals or poor network conditions increase transmission delays (Brown et al., 2016). Overall, validation results confirm the RFID subsystem’s strong reliability, while SMS notifications remain influenced by technical and human factors. This aligns with SDG 9 on innovation and the Socio-Technical Systems Theory (Trist & Emery, 1981), emphasizing that successful technology use requires coordination between technical tools, users, and operational processes. Automated RFID attendance improved data recording, reduced manual work, and enhanced accountability, but SMS efficiency still depends on network stability and system management.

*The efficiency of the automated attendance monitoring.*

This section examined the efficiency of the automated attendance monitoring system by measuring the time difference between each RFID tap and the corresponding SMS notification, recording errors, and assessing system responsiveness during peak hours. Data were gathered across the three testing phases: Baseline, Adjustment, and Validation.

Mean Time Difference (sec)	Efficiency Level	Description
1 – 30	Efficient	SMS is delivered almost in real-time

<b>31 – 60</b>	Moderately Efficient	Some delay, but acceptable
<b>61 and above</b>	Not Efficient	Noticeable delay; slow delivery

*Table 7. Efficiency Scale of SMS Delivery Based on Mean Time Difference*

The efficiency scale presented above was used to interpret the mean time difference between RFID scans and SMS notifications. Each computed mean delay was classified into one of three efficiency levels, which are Efficient, Moderately Efficient, or Not Efficient, based on the length of time required for message delivery.

*Time difference*

This section focused on evaluating the efficiency of the automated attendance monitoring system during student entry by measuring the time difference between each RFID entry scan and the corresponding SMS notification sent to parents or guardians. The total delay and mean time difference across three trial phases were analyzed to determine the responsiveness of the SMS notification feature during entry monitoring.

Trial	Total Successful Entry SMS	Total Delay Time (sec)	Mean Time Difference (sec)	Efficiency Level
<b>Trial 1 (Baseline)</b>	24	2040	85	Not Efficient
<b>Trial 2 (Adjustment)</b>	28	1140	40.71	Moderately Efficient
<b>Trial 3 (Validation)</b>	57	24,300	426.32	Not Efficient

*Table 8. Entry SMS Time Difference*

This section focused on evaluating the efficiency of the automated attendance monitoring system during student entry by measuring the time difference between each RFID entry scan and the corresponding SMS notification sent to parents or guardians. The total delay and mean time difference across three trial phases were analyzed to determine SMS responsiveness. Table 8 presents these results. During Trial 1 (Baseline), 24 successful SMS messages were recorded, with a total delay of 2,040 seconds, yielding a mean of 85 seconds, indicating inefficient delivery. In Trial 2 (Adjustment), 28 SMS notifications were sent with a reduced total delay of 1,140 seconds, yielding a mean of 40.71 seconds, showing improved responsiveness. In Trial 3 (Validation), 57 messages were sent, but total delay rose to 24,300 seconds, producing a mean of 426.32 seconds, and some notifications took up to two hours. This extreme delay is attributed to network congestion and 2G GSM limitations, which handle SMS through shared channels with limited capacity. Despite delays, the RFID subsystem accurately recorded attendance, showing the core system is reliable. SMS performance varied with network conditions and load. Bhingarde and Parulekar (2018) note that RFID ensures accurate logging, while SMS depends on signal strength and network stability. Studies also show that high user density and congestion in 2G networks can cause unpredictable delays (Leo et al., 2016). Overall, RFID remains highly reliable, while SMS efficiency depends on external network factors.

Trial	Total Successful Exit SMS	Total Exit Delay Time (sec)	Mean Exit Time Difference (sec)	Efficiency Level
<b>Trial 1 (Baseline)</b>	42	660	15.71	Efficient
<b>Trial 2 (Adjustment)</b>	36	9,900	275	Not Efficient
<b>Trial 3 (Validation)</b>	57	13,620	238.95	Not Efficient

*Table 9. Exit SMS Time Difference*

This section evaluated the efficiency of the automated attendance system during student exit by measuring the time between each RFID scan and its corresponding SMS notification. Total exit delay and mean time difference were analyzed across three testing phases to assess responsiveness. In Trial 1 (Baseline), 42 SMS messages were recorded with a total delay of 660 seconds, yielding a mean of 15.71 seconds, indicating timely delivery. In Trial 2 (Adjustment), 36 messages were recorded, but total delay rose to 9,900 seconds, with a mean of 275 seconds, showing adjustments did not immediately improve performance. In Trial 3 (Validation), 57 messages were recorded, yet total delay increased to 13,620 seconds, with a mean of 238.95 seconds, suggesting that while RFID logging remained accurate, SMS delivery slowed due to higher usage and GSM network conditions. Overall, RFID ensured reliable attendance, whereas SMS performance fluctuated with system load and network factors. This supports Ishaq and Bibi (2023), who noted that RFID is dependable while SMS depends on network stability, and Musa and Adeniran (2022), who reported that congestion and strained signaling can delay or block messages.

Trial	Total Taps	Missed Scans	Error Rate (%)	Remarks
<b>Trial 1</b>	166	20	12.05	System interruption on Day 5
<b>Trial 2</b>	160	0	0	Fully reliable
<b>Trial 3</b>	164	0	0	Fully reliable

Table 10. Number of Errors or Missed Scans

This section focused on evaluating the accuracy and reliability of the RFID attendance system by analyzing the total number of RFID taps and the corresponding missed scans across three trial phases, with error rates calculated to determine how consistently the system captured attendance data without interruptions or loss. Table 10 presents the numbers of RFID taps, missed scans, and error rates across the three trials. In Trial 1, the system recorded 166 taps and 20 missed scans, resulting in an error rate of 12.05%, whereas Trials 2 and 3 registered no missed scans, yielding 0% error and indicating a clear improvement in data capture accuracy after the baseline phase. The large reduction in missed scans suggests that the initial errors were not persistent system faults but were linked to specific operational issues, as the 20 missed scans on Day 5 were mainly caused by a power failure and an RFID reader malfunction that prevented several time-in records from being captured. Once resolved, the system performed without missed scans in subsequent trials, demonstrating greater stability and consistency. Overall, these results confirm the improved accuracy and reliability of the RFID system, as the reduction from 20 missed scans in Trial 1 to zero in Trials 2 and 3 shows that the initial errors were caused by temporary operational problems rather than inherent system flaws. This finding is supported by Mazlan and Ahmad (2025), who reported that RFID-enabled attendance systems significantly enhance tracking accuracy and reduce human recording errors once properly configured and tested, and by Hemavathi et al. (2024), who explained that automated attendance systems improve reliability and minimize data inaccuracies when technical disruptions are resolved. These studies align with the present findings, showing that correcting the power interruption and RFID reader malfunction led to a 0% error rate in subsequent trials, demonstrating that the system can achieve high accuracy and stable performance after proper troubleshooting and optimization.

*System responsiveness during peak hours*

This section focused on evaluating the system’s responsiveness during peak entry hours by analyzing how quickly SMS notifications were delivered when multiple students tapped their RFID cards within a short time frame. The percentage of SMS messages successfully delivered within one minute during the 5:40–6:10 AM peak window was used to determine the system’s real-time performance under high-traffic conditions.

Trial Phase	Peak Hour Window	Peak Hour Scans	SMS Delivered Within 1 Minute	Responsiveness (%)
<b>Trial 1 (Baseline)</b>	5:40–6:10 AM	33	8	24.24
<b>Trial 2 (Adjustment)</b>	5:40–6:10 AM	25	5	20
<b>Trial 3 (Validation)</b>	5: 40–6:10 AM	43	22	51.16

Table 11. System Responsiveness During Peak Entry Hour

Table 11 shows the system's responsiveness during peak entry hours (5:40–6:10 AM) across the three trial phases. In Trial 1 (Baseline), 33 RFID scans were recorded, but only 8 SMS notifications were delivered within one minute, yielding a responsiveness rate of 24.24%. In Trial 2 (Adjustment), 25 scans resulted in 5 timely SMS messages, producing the lowest responsiveness rate of 20%. In Trial 3 (Validation), responsiveness improved with 43 scans and 22 SMS delivered on time, raising the rate to 51.16%. The low responsiveness in Trials 1 and 2 indicates delays in sending SMS notifications during peak hours, as the system struggled to process multiple simultaneous scans. Trial 3 improvements show that system adjustments helped, but rates remained below 60%, meaning many SMS messages were still delayed under high traffic. Overall, RFID logging remained reliable, but SMS delivery was affected by system load and GSM network constraints, consistent with Singhal and Gujral (2012), who noted that SMS-based attendance systems are prone to delays under heavy usage.

Trial Phase	Peak Hour Window	Peak Hour Scans	SMS Delivered Within 1 Minute	Responsiveness (%)
<b>Trial 1 (Baseline)</b>	11:40 AM–12:10 PM	37	25	67.57
<b>Trial 2 (Adjustment)</b>	11:40 AM–12:10 PM	59	48	81.36
<b>Trial 3 (Validation)</b>	11:40 AM–12:10 PM	66	30	45.45

Table 12. System Responsiveness During Peak Exit Hours

This section evaluated the system's responsiveness during peak exit hours by measuring how efficiently SMS notifications were delivered within one minute when multiple students scanned their RFID cards. Timely SMS delivery during the 11:40 AM–12:10 PM peak window was used to assess real-time performance under high volume. Table 12 shows that in Trial 1 (Baseline), 37 RFID scans yielded 25 timely SMS messages, a responsiveness rate of 67.57%. In Trial 2 (Adjustment), 59 scans produced 48 on-time messages, the highest rate at 81.36%, indicating that system adjustments temporarily improved SMS delivery during moderate scan volumes. In Trial 3 (Validation), responsiveness dropped: 66 scans produced only 30 timely messages, a 45.45% rate, showing that performance declined as scan volume increased. Overall, while the RFID subsystem reliably recorded attendance, the GSM module for SMS was affected by high system load and network constraints, consistent with other studies showing that GSM-based SMS performance fluctuates under heavy usage (Reddy et al., 2025).

Trial Phase	Total Days Observed	Days Without Error	System Interruption	Stability Rate (%)	Remark
<b>Trial 1</b>	5	4	1	80.00	One interruption on day 5
<b>Trial 2</b>	5	4	1	80.00	Minor system downtime
<b>Trial 3</b>	5	5	0	100.00	Fully Stable

Table 13. The reliability of the RFID attendance system

This section examined the reliability of the RFID attendance system in terms of continuous operation, maintenance, and data storage, with interruptions, repairs, and data retrieval monitored across the three testing phases. Table 13 shows that in Trial 1, the system ran without error for 4 of 5 days, achieving a stability rate of 80%, indicating general reliability despite a minor disruption. Trial 2 maintained the same rate, suggesting persistent minor technical issues. In Trial 3, the system operated flawlessly for all 5 days, reaching 100% stability, showing that earlier issues were resolved. Overall, the system functioned properly on 13 of 15 days, yielding an 86.67% reliability rate, demonstrating dependable continuous performance when properly configured. This aligns with Aníñon et al. (2020), who noted that RFID systems provide automated, accurate tracking, reduce manual errors, and improve operational stability, though initial adjustments may be needed. However, SMS delivery during peak hours remained inconsistent, with responsiveness reaching only 51.16% in

Trial 3, showing delays when multiple RFID scans occurred. This indicates that while RFID logging was reliable, SMS notifications were affected by network and operational constraints, consistent with the Socio-Technical Systems (STS) Theory of Trist and Emery (1981). It also supports SDG 9 on innovation and infrastructure and aligns with Singhal and Gujral (2012), who observed that SMS-based RFID systems are highly dependent on network performance and may experience delays under heavy usage.

Trial Phase	Longest Continuous Run (Days)	Reset/Repair Required?	Remark
Trial 1	4	Yes	Restart after Day 5 failure
Trial 2	4	Yes	System paused on Day 10
Trial 3	5	No	No interruption

Table 14. How system works before needing repairs

This section evaluated how long the RFID attendance system can operate continuously before requiring a reset or repair, observing the system’s longest run, interruptions, and maintenance needs across the three trial phases. Table 14 shows that in Trial 1, the system ran for 4 consecutive days before failing on Day 5, and in Trial 2, it also operated 4 days before pausing on Day 10 for maintenance. These results indicate that during initial trials, the system maintained short-term operation, though interruptions occurred after several days, suggesting limits in prolonged stability. In Trial 3, the system achieved its longest uninterrupted run of 5 days, showing slight improvement compared to previous trials. Overall, the RFID system can reliably operate for about 4–5 days before the likelihood of malfunction rises, with resets or repairs needed in two of three trials, reflecting moderate reliability influenced by hardware, environment, or system load. This aligns with Reyes et al. (2016), who noted that RFID performance depends on integration quality, infrastructure stability, and maintenance practices. While RFID improves automation and efficiency, sustained operation requires regular monitoring and technical support.

Trial Phase	Records Stored	Records Retrieved	Data Loss	Retrieval Rate (%)	Remark
Trial 1	146	146	0	100.00	All records accessible
Trial 2	141	141	0	100.00	No data loss
Trial 3	157	157	0	100.00	Fully secure

Table 15. Secure and Accessible Student Attendance Records

This section focused on the security and accessibility of the RFID attendance system, evaluating data storage, retrieval accuracy, and data loss prevention across three trial phases. Table 15 presents the number of records stored, records retrieved, data loss, and overall retrieval rate. In Trial 1 (Baseline Testing), 240 attendance records were stored, all of which were successfully retrieved, resulting in zero data loss and a 100% retrieval rate, indicating that the system securely stored students’ attendance data and ensured full accessibility. In Trial 2 (Adjustment), the stored records increased to 270, yet all records were again retrieved without loss, maintaining a 100% retrieval rate and demonstrating reliable performance even with larger data volume. In Trial 3 (Final Validation), 300 records were stored and fully retrieved, preserving a 100% retrieval rate, which shows that the system consistently maintained strong data integrity throughout testing. Remarks such as “All records accessible,” “No data loss,” and “Fully secure” further emphasize the dependable performance. Overall, the findings indicate that the RFID attendance system accurately records, securely stores, and reliably retrieves attendance data. This aligns with Ishaq and Bibi (2023) in *IoT-Based Smart Attendance System Using RFID: A Systematic Literature Review*, who reported that RFID-based systems enhance data accuracy, minimize errors, and ensure reliable recordkeeping when properly implemented, confirming that RFID technology is a dependable solution for safely storing and accessing attendance information.

## Conclusion and Implications

### *Conclusion*

This study evaluated the effectiveness of the RFID-Enabled ID System with SMS Notification Features in monitoring student attendance at Maguikay High School and found the system to be highly accurate in recording student entries and exits with minimal discrepancies. Although SMS notifications occasionally experienced delays due to network conditions, overall efficiency improved as errors and missed scans were minimized after system adjustments, and attendance records were securely stored and easily retrievable, demonstrating reliability. Anchored in the Sociotechnical Systems Theory by Eric Trist and Fred Emery (1981), the study confirms that the effective integration of technological systems (RFID technology) and social systems (students and researchers) enhances organizational performance and efficiency. Furthermore, the findings support the goals of the United Nations under Sustainable Development Goal 9, which promotes innovation and resilient infrastructure, as the creation of this system strengthens digital transformation in educational institutions. Based on these results, the null hypothesis ( $H_0$ ), which states that the system will not significantly improve the efficiency of student attendance tracking, is rejected.

### *Recommendations*

Based on the findings and conclusions of this study, the following recommendations are proposed:

**School Administrators.** Fully implement and expand the RFID-enabled attendance monitoring system to other grade levels to enhance school-wide attendance management.

**ICT Personnel and Technicians.** Conduct regular system maintenance and periodic testing to ensure long-term reliability and prevent technical disruptions.

**Teachers and Students.** Encourage teachers and students to provide feedback on the system's usability to identify areas for improvement and enhance the user experience. Participate in orientation and training programs to ensure proper usage and maximize system effectiveness.

**Parents/Guardians.** Provide guides on understanding SMS notifications and interpreting attendance reports to support their child's attendance habits actively.

**Future Researchers.** Conduct further studies comparing the RFID-based attendance monitoring system with commercial systems to determine whether there is a significant difference in accuracy, efficiency, reliability, cost-effectiveness, scalability, and user satisfaction. Statistical analysis may be used to identify measurable differences between the developed system and commercially available systems. This will help evaluate the system's competitiveness and provide a basis for future improvements.

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## Data Availability Statement

Data sharing is only available upon submitting a formal request to the authors.

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## Appendices

No appendices are attached to this study.