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Design and Development of an Rfid-Based Student Attendance System Using Student ID Cards as Identification Media and Local Mysql Recording

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ABSTRACT

This study designs and develops an RFID-based student attendance system to address common shortcomings of conventional attendance methods, including time inefficiency, proxy attendance, and recording errors. The proposed solution uses RFID-enabled student ID cards (KTM) as the identification medium, integrates an ESP32 microcontroller with an RC522 reader, and logs attendance to a web application connected to a local MySQL database with an automated Excel export feature. The work follows a research-and-development (R&D) prototyping approach consisting of requirements analysis, system design, implementation, and iterative testing. System performance was examined through functional tests and empirical evaluation. Functional testing shows that card identification is reliable with an average read latency of 0.1 s and real-time database recording. Content validity was assessed by expert reviewers (n = 4) using Aiken's V, yielding an overall index of 0.982, indicating high feasibility. Practicality and usability were evaluated through a limited trial with 15 students using a 5-point Likert questionnaire; responses were analyzed using descriptive statistics (mean scores). The overall user rating averaged 4.85/5, reflecting strong acceptance and ease of use. The results indicate that the proposed RFID–ESP32–MySQL system can improve efficiency, transparency, and report readiness in student attendance management.

I. Introduction

Student attendance is a core indicator of academic participation and responsibility. Consistent attendance reflects learning motivation and discipline, and it is frequently used as an administrative basis for monitoring engagement and compliance in higher education. Prior work notes that regular attendance is closely associated with students' commitment to the learning process [1]. However, many universities especially in developing contexts—still rely on manual attendance lists, such as paper signatures or roll calls. These practices are time-consuming, prone to recording errors, and vulnerable to manipulation and proxy attendance [2].

Recent advances in information technology have enabled automation across administrative tasks, including attendance. Radio Frequency Identification (RFID) is widely adopted as a contactless identification method that reads tag data via radio waves [3]. In educational settings, RFID can accelerate attendance capture, improve record accuracy, and reduce cheating such as buddy-signing [4]. Using student ID cards (Kartu Tanda Mahasiswa, KTM) that already contain an RFID chip is particularly practical because the card can function both as an identity credential and as an attendance token.

Although many studies have implemented RFID attendance systems, a significant portion depends on complex infrastructure such as GSM, IoT gateways, or cloud services, which are not always available or sustainable for institutions with limited resources [5], [6]. Other limitations include unstable tag reading in crowded environments, suboptimal data synchronization, and relatively high

deployment costs [7]. These gaps indicate the need for a simpler, efficient solution that can operate locally (offline/localhost) without external internet dependence, while still providing reliable and auditable attendance records.

This study therefore designs and develops an RFID-based student attendance system that uses an ESP32 microcontroller and KTM cards as the identification medium. The system integrates with a local MySQL database and provides an automated export feature to Microsoft Excel to support academic reporting workflows. Using a Research and Development (R&D) approach with prototyping, the work emphasizes iterative implementation, expert validation, and limited user testing to assess functional feasibility and practical usability. Scientifically, the study contributes empirical evidence on low-cost RFID adoption in higher education administration; practically, it offers a cost-effective and deployable digital attendance solution that supports academic governance digitalization [3].

A. Literature Review

An attendance system is a key instrument in academic management because it records and controls student presence in a systematic way. In the context of information system management, technology-enabled attendance is used to improve administrative efficiency and data accuracy. Automated attendance systems show measurable advantages over manual methods, particularly in speed and precision [8]. Electronic attendance supported by automatic identification belongs to the broader field of Automatic Identification and Data Capture (AIDC), where RFID is often regarded as one of the most efficient contactless identification technologies.

RFID uses radio waves to read and store data from tags or transponders. A typical RFID system consists of a reader, an antenna, and a tag that uniquely identifies an object. Tags can be passive or active: passive tags have no internal power source and activate only when energized by the reader, while active tags use an internal battery for transmission [9]. Because RFID can capture data quickly and accurately without physical contact, it is suitable for student attendance logging [10]. In this study, RFID is combined with KTM cards so that a single credential supports both identity verification and automated attendance capture.

The ESP32 is an open-source microcontroller widely used in Internet of Things (IoT) prototyping. It includes Wi-Fi and Bluetooth connectivity and can be integrated with sensors such as the RC522 RFID module. ESP32 is commonly selected for educational and low-cost deployments due to its affordability, large developer community, and ease of database integration [11]. The ESP32–RFID combination enables a responsive attendance workflow and can be made compatible with administrative tools such as Microsoft Excel [12].

Several prior studies have investigated RFID-based attendance. Rjeib et al. developed a web-based RFID attendance system that records presence in real time, reporting improvements in transparency and administrative efficiency [13]. A systematic literature review by Ishaq and Bibi concludes that RFID-based approaches can be cost-effective and relatively easy to deploy in educational institutions [14]. However, some systems require GSM-based transmission, which increases operational cost and adds infrastructure dependencies [15]. To reduce complexity, other work recommends simpler approaches such as exporting records directly to spreadsheet formats for small-to-medium institutions [8]. Comparative evaluations also indicate that RFID can be faster than biometric fingerprint systems with a lower error rate under certain operational conditions [16]. On the other hand, adding advanced features such as automated Telegram notifications can increase technical complexity and hinder adoption in resource-constrained environments [7]. Beyond attendance, IoT automation studies (e.g., visitor counting) also demonstrate that microcontroller-based logging can raise recording accuracy and reduce manual workload [17]. Prior studies show that low-cost microcontrollers such as Arduino can be used to acquire and monitor sensor data in real time, supporting practical embedded-system implementations for monitoring and reporting [28].

Despite the demonstrated effectiveness of RFID, key research gaps remain. Many deployments depend on internet/cloud services that are difficult to sustain in limited-infrastructure institutions [5], [6]. Research that explicitly integrates RFID with student ID cards as the primary credential remains limited, even though it can streamline academic administration in Indonesian universities.

Additionally, small institutions often benefit from local, offline (localhost) architectures that avoid external server dependencies [18]. Finally, expert validation and user acceptance are frequently underreported, limiting empirical evidence about practical feasibility.

Based on this literature, the present study contributes an RFID–ESP32 attendance system integrated directly with a local MySQL database and an Excel reporting feature. The system is designed for deployment without external internet connectivity while maintaining real-time recording, usability, and operational sustainability in higher education settings.

II. The Proposed Method/Algorithm

B. System Architecture

The proposed system integrates an RFID reader (RC522) with an ESP32 microcontroller as the front-end acquisition device and a local web server as the back-end processing unit. The ESP32 reads the unique identifier (UID) from the student card (KTM) and transmits the UID along with a timestamp through a local network to a PHP-based application. The application validates the UID against the student database, records attendance into a local MySQL database, and provides an administrative dashboard for monitoring and reporting. An Excel export module generates structured attendance reports to minimize manual re-entry and reduce administrative errors. The overall system architecture is shown in Figure 1.

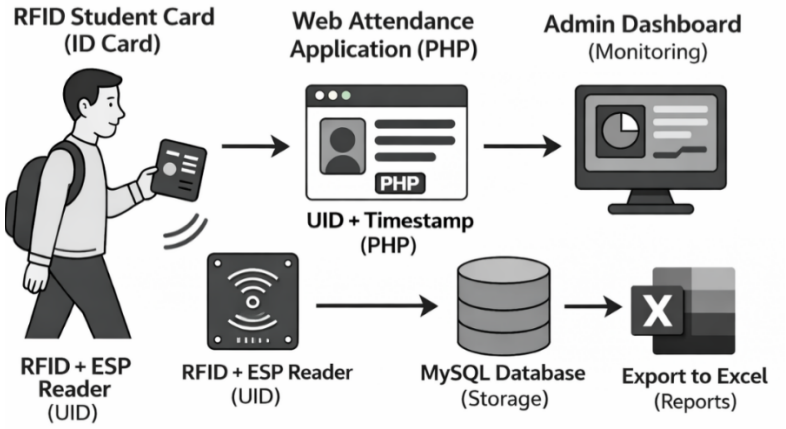

Fig. 1. System architecture of the RFID–ESP32 web attendance system and reporting pipeline

C. Operational Flow

Operationally, the workflow consists of (1) card tapping at the reader, (2) UID capture by ESP32, (3) UID submission to the local server endpoint, (4) validation and attendance logging in MySQL, and (5) report generation and export in Excel format. This offline-first design allows the system to function without external internet access, which is relevant for institutions with limited infrastructure while still maintaining transparency and traceability of attendance data. This operational sequence is illustrated in Figure 2.

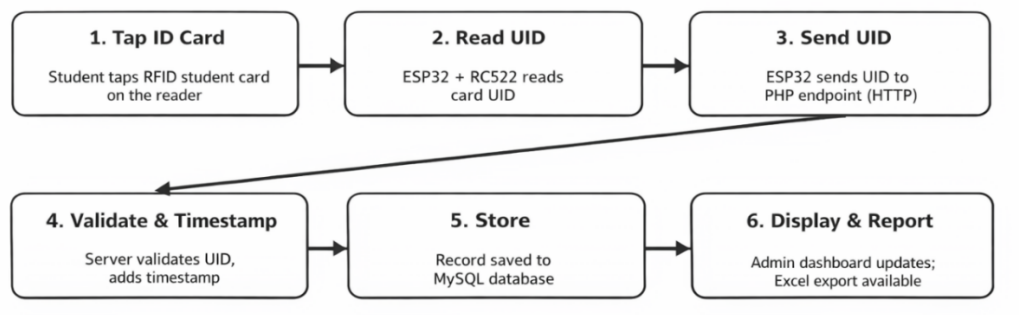

Fig. 2. Operational flow of the RFID–ESP32 attendance process.

III. Method

This study adopts a Research and Development (R&D) approach using prototyping as the main development strategy. R&D is appropriate because the objective is to produce an educational technology artifact and evaluate it functionally and empirically through systematic stages such as design, testing, validation, and refinement [19]. The Prototype Development Life Cycle (PDLC) is used because it supports rapid iterations between design, user trials, and revisions based on feedback [20]. This approach aligns with the goal of building an automated attendance system using an ESP32 microcontroller and RFID-enabled student ID cards (KTM).

The study was conducted at Universitas Bina Bangsa Getsempena, Banda Aceh, in the 2024/2025 academic year. The site was selected because attendance was still managed manually, enabling direct comparison with the proposed automated workflow. Data collection and prototype testing were carried out over approximately three months and included observation, system design, functional testing, expert validation, and a limited field trial with students.

The population consisted of active students in the Computer Science program. A purposive sample of 15 students participated in the user trial based on availability and involvement in classes using the prototype. This sample size is considered sufficient for limited prototyping evaluation in development research. In addition, four experts in information systems, software engineering, and educational technology served as validators to assess system feasibility using an Aiken's V-based instrument [21].

Two instruments were used: (1) an expert validation sheet comprising seven core feasibility indicators (RFID reading accuracy, data recording reliability, system response time, interface usability, feature completeness, export quality, and system stability), and (2) a user questionnaire to evaluate practicality and student satisfaction. Content validity of the expert instrument was measured using Aiken's V, while the user instrument was evaluated through consistency of field trial results. A 5-point Likert scale (1–5) was applied for all items.

Data collection consisted of observation, functional testing, and an evaluative questionnaire. Observation was used to identify weaknesses of the prior manual attendance process. Functional testing assessed RFID read accuracy, timestamp correctness, and stability of the integration with the local MySQL database. After using the system, students completed the questionnaire to rate ease of use, speed, and perceived convenience.

Collected data were analyzed using descriptive quantitative methods. Expert validation scores were analyzed by computing Aiken's V to estimate inter-rater agreement regarding system feasibility [21]. Student questionnaire responses were analyzed using mean scores, standard deviation, and the percentage of positive responses to summarize user acceptance. Basic spreadsheet tools were used to support calculations and interpretation.

IV. Results and Discussion

This study produced an RFID-based student attendance system that uses KTM cards as the identification medium and an ESP32 microcontroller as the main controller. The system integrates with a local MySQL database and a localhost web interface, and it supports exporting attendance records to Microsoft Excel for academic documentation. The final product provides two main operational modes: a card registration mode (for adding student data) and an attendance mode (for automated presence logging). Students simply tap their KTM card on the RFID reader; the system then stores the attendance record in the local database and updates the admin page in real time. An anonymized example of the generated Excel report is shown in Figure 3.

No.	UID	Name	Student ID	Class	Date	In	Out	Remarks
1	**:**:**:**	Student A	22xxxxxx	CBT-A	2025-10-24	16:28	17:37	Present
2	**:**:**:**	Student B	22xxxxxx	CBT-A	2025-10-24	16:26	16:27	Present
3	**:**:**:**	Student C	22xxxxxx	CBT-A	2025-10-24	16:26	16:28	Present
4	**:**:**:**	Student D	22xxxxxx	CBT-A	2025-10-23	21:09	22:15	Present
5	**:**:**:**	Student E	22xxxxxx	CBT-A	2025-10-23	20:56	21:05	Present

Fig. 3. Example of the exported attendance report (Excel format, anonymized).

Expert validation was conducted across seven core functional aspects using Aiken's V [21]. All aspects achieved $V \geq 0.875$ with an overall average of $V = 0.982$, which indicates very high validity. The highest scores ($V = 1.000$) were obtained for RFID reading accuracy, data storage reliability, response speed, Excel export quality, and system stability. The lowest score ($V = 0.875$) concerned the admin interface, where validators suggested improvements in visual layout and navigation [22]. Overall, experts deemed the system feasible for direct user trials. Detailed results are summarized in Table 1 and visualized in Figure 4.

Table 1. Expert validation results using Aiken's V (n = 4 experts).

No.	Expert-evaluated aspect	Aiken's V
1	The system reads the student ID card correctly on every tap	1.000
2	Attendance data are stored in the database immediately without errors	1.000
3	The time from tap to data storage feels fast/responsive (low latency)	1.000
4	The admin interface is easy to understand and use	0.875
5	Search, filtering, and recap features meet administrative needs	1.000
6	The exported Excel report (CSV/XLSX) is well-formatted and easy to analyze	1.000
7	The system remains stable during repeated taps (high traffic)	1.000

Overall Aiken's V average: 0.982.

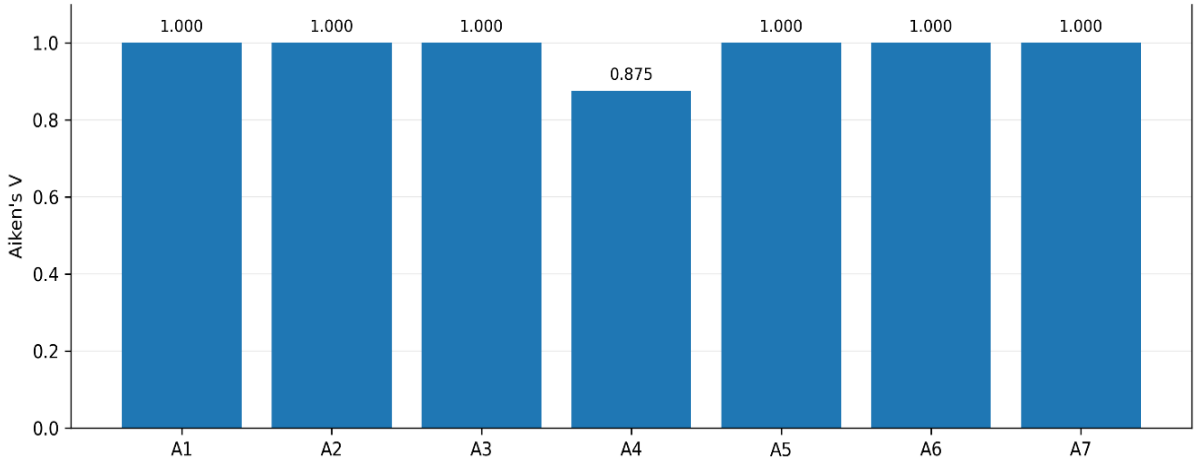

Fig. 4. Expert validation scores (Aiken's V) across seven system aspects.

A user trial was conducted with 15 students through an in-class attendance simulation. Using a 5-point Likert questionnaire, the overall mean score was 4.85, indicating very high acceptance and satisfaction. All respondents reported that the KTM tap process was easy and did not disrupt classroom activities. The highest-rated aspect was attendance speed (mean 4.93), while device accessibility received the lowest score (mean 4.73) because the reader placement was not optimal for all users. Field observations further showed that the system recorded attendance consistently without data loss when used sequentially by multiple students. Attendance results could be downloaded directly as Excel/CSV with a tabular structure containing student identity, attendance time, and status, which supports rapid recap and archival by lecturers and administrators. A summary of student responses is provided in Table II and visualized in Figure 5.

TABLE II. Student trial questionnaire results (n = 15).

No.	Statement (student trial)	Mean (1–5)	SD	Agree (%)
1	I understand the instructions for tapping the student ID card	4.87	0.35	100.0
2	The tapping process is fast and does not disrupt class activities	4.93	0.26	100.0
3	After tapping, my attendance status is confirmed on-screen	4.80	0.41	100.0
4	The reader location and position are easy to reach	4.73	0.80	93.3
5	Overall, ID-card attendance is more practical than manual attendance	4.93	0.26	100.0
	Overall average	4.85		

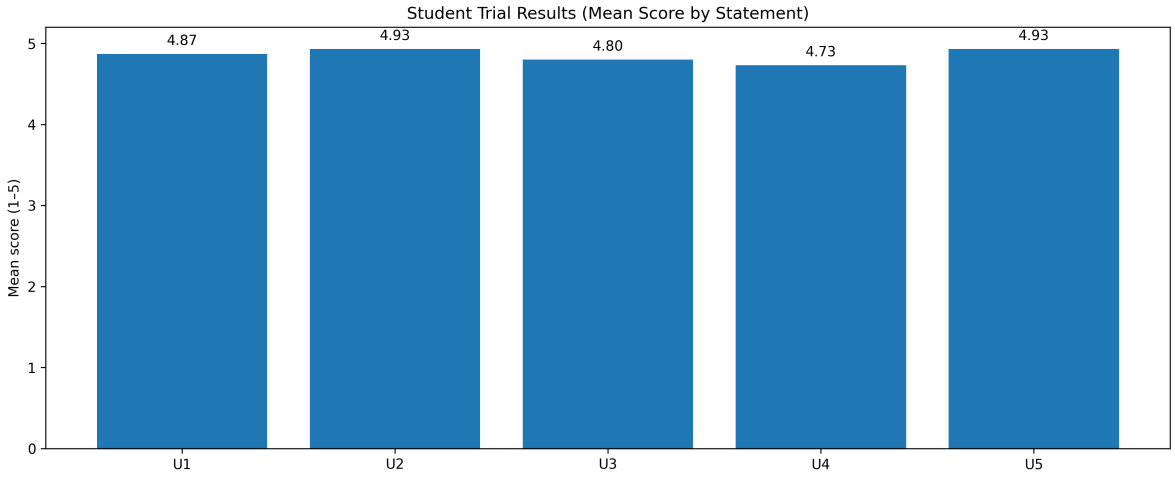

Fig. 5. Student trial mean scores across five usability statements.

These findings indicate that RFID–ESP32–MySQL integration can deliver an effective automated attendance system in higher education without requiring external internet infrastructure. The strong expert-validity score supports the system's functional feasibility [21], and is consistent with prior evidence that RFID enables fast and accurate attendance capture [13], [14]. High user acceptance also aligns with usability engineering principles that emphasize learnability, efficiency, and user satisfaction in interface design [22].

From a theoretical perspective, the system reinforces the AIDC concept where RFID enables contactless digital identification [9]. Practically, using ESP32 and a localhost architecture enables operation without internet connectivity, which is particularly relevant for institutions with limited infrastructure [18]. This design also supports low-cost deployment priorities highlighted in earlier studies [4]. In terms of reporting, automated Excel export accelerates documentation and reduces human error risk, echoing recommendations for spreadsheet-based outputs in small-to-medium institutions [8]. Moreover, RFID-based workflows can reduce manipulation practices such as proxy signatures, improving academic administrative integrity [10].

Two important considerations emerged. First, ergonomics: several students noted that the RFID reader position should be adapted to classroom layout and user height to maximize comfort. Second, security: the current system relies on single-factor RFID card identification. Consistent with findings

that RFID-only systems may face card-proxy risks [23], future work should add a second authentication factor such as fingerprint or facial recognition to strengthen attendance validity.

This study also confirms that an R&D prototyping approach can effectively guide the development of microcontroller-based attendance systems and support empirical feasibility assessment. The iterative cycle produced a system with high validity and strong user acceptance [19]. However, limitations include the small trial scope (one program, limited respondents) and the lack of biometric security integration. Future research should expand trials across faculties, introduce two-factor authentication, and consider LAN-based connectivity for broader institutional deployment. Integration with a Learning Management System (LMS) may also enable longitudinal attendance analytics.

V. Conclusion

This research successfully designed and developed an RFID-based student attendance system that uses KTM cards as the identification medium, is controlled by an ESP32 microcontroller, and is integrated with a local MySQL database. The system supports automatic attendance recording in real time and provides an Excel export feature to facilitate academic reporting.

Expert validation using Aiken's V produced an overall index of 0.982, indicating very high feasibility. User testing with 15 students yielded an average score of 4.85 out of 5, demonstrating that the system is practical and easy to use.

Based on these results, the RFID attendance system can serve as an effective alternative to manual attendance procedures. Further improvements are recommended to optimize device placement and to strengthen security through additional authentication mechanisms for wider deployment.

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