



Towards an RFID-Based Student Attendance Management System in Higher Education: Objectives, Requirements, and Theoretical Underpinnings

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Abstract

Accurate record-keeping of students' class attendance in higher education institutions has been a big challenge. The Radio Frequency Identification (RFID) System has been suggested to be possible solution to this challenge. Therefore, this study investigated the objectives and requirements for developing a Radio Frequency Identification (RFID)-based Student Attendance Management System (SAMS) at the University of Nigeria, Nsukka. The study adopted the Research and Development (R&D) design. A sample of 72 academic staff from two departments was selected through a total sampling technique. A validated questionnaire with a reliability coefficient of 0.86 was used to collect data for the study. The descriptive statistics of mean and standard deviation were used for data analysis. The results show that the respondents agree that RFID systems enhance accuracy, efficiency, security, and real-time monitoring of students' attendance. It was recommended that the universities should use RFID-based attendance systems since it has the promise of increasing school efficiency and supporting student academic performance.

Keywords: Educational Technology Adoption; Higher Education Policy; Nigerian University Commission (NUC); Radio Frequency Identification (RFID); Student Attendance Management

Introduction

The rapid technological evolution and the increasing students' enrolment in institutions of higher learning have raised critical concerns about how best to track students' class attendance records. Attendance, often viewed as a mundane administrative task, is actually one of the most reliable indicators of a student's academic performance, persistence in school, and overall success (Enderle et al., 2024). However, it has been found that many schools in Nigeria and around the world still use the outdated manual attendance capturing systems such as roll calls, paper registers, and handwritten signatures. It has been found that these systems waste critical teaching time and provide opportunities for fraud, mistakes, and inefficiencies to occur.

Recent studies indicate that efficient attendance tracking systems have a favourable impact on educational outcomes by ensuring compliance, increasing student involvement, and facilitating academic oversight (Bugingo et al., 2025). Biometrics, QR codes, and RFID technologies have also been utilised in various other situations, demonstrating their ability to enhance efficiency and

accuracy (Nguyen, 2024). Still, it seems that there have not been enough in-depth studies on the objectives and requirements that should shape the design of RFID-based attendance management systems in higher education. Furthermore, previous studies have primarily focused on technological feasibility and pilot deployments (Gadke et al., 2021). However, they disregard the interplay of institutional regulations, educational prerequisites, and theories of technological adoption that affect the successful integration of such systems in higher education institutions.

Although there are potential benefits to RFID systems, most studies have only examined the engineering or hardware aspects, rather than the educational or administrative aspects of higher education (Miranda et al., 2021). Some related studies were conducted in small-scale experiments that did not assess the institution's readiness to adopt this technology (Rogers, 2003). Research has often overlooked issues such as system scalability, privacy concerns, and adherence to institutional regulations. Additionally, there is a limited understanding of

what makes an RFID attendance tracking system technically effective and useful for teaching, as a gap exists in this area. To address this shortcoming, we examined the objectives and requirements for developing an RFID-based student attendance management system within a university setting. We selected the University of Nigeria in Nsukka as an example.

Literature Review

In this section, we look at previous research that investigated the objectives and requirements for making an RFID-based student attendance management system (SAM). The studies examined indicate that precise monitoring of student attendance is essential for efficient academic administration. These advantages are associated with elevated accountability, academic advancement, and student retention (Moores et al., 2019; Patrick et al., 2016). Also, it is well known that many colleges and universities in developing nations still utilise paper registers, roll calls, and signing sheets to keep track of students. These strategies are no longer effective because class sizes are increasing, policies are making schools more accountable, and schools require rapid access to accurate data. The research also shows that the existing manual techniques for taking attendance consume a significant amount of time and disrupt the flow of instruction. This is typical in large lecture rooms, where it takes a long time and compromises the quality of instruction (Balzer et al., 2020).

Additionally, manual systems have been shown to facilitate student engagement in academic dishonesty, exemplified by proxy attendance, wherein individuals sign in for absent peers (Selwyn et al., 2021). It's also impossible to integrate, search, or look at manual attendance records. This makes it not good for long-term reporting or predictive analytics. As more students enrol in schools, it has become increasingly challenging and impractical for teachers to collect, calculate, and report attendance (Kearney et al., 2023). This literature has shown that although the manual system appears inexpensive, its long-term inefficiencies and cumulative errors create significant institutional costs. Hence, continued reliance on manual methods is a barrier to modernising academic administration, resulting in a need for a digital attendance solution (Moshayedi et al., 2024).

A study conducted by Sá et al. (2023) shows that students with regular attendance perform better academically than those with inconsistent attendance patterns. High attendance is also associated with increased likelihood of graduation

(Stargel et al., 2022). Hence, attendance has evolved into a meaningful analytic indicator, used not only to verify compliance but also to support early warning systems and learning analytics initiatives. Also, systems such as biometric authentication (fingerprint, iris, facial recognition), QR codes, and Radio Frequency Identification (RFID) have been piloted in previous studies. The following was found concerning RFID system including: the biometric systems are accurate, they require costly infrastructure and raise privacy concerns (Neo et al., 2022). Although the QR code-based systems are low-cost, they require manual scanning and are susceptible to duplication. RFID technology is becoming more popular, though, because it allows for automatic, contactless identification (Xu et al., 2023). The RFID system comprises tags, readers, antennas, middleware, and databases that collaborate to rapidly collect and transmit attendance data (Costa et al., 2021; Haibi et al., 2023).

Mahajan et al. (2024) carried out a study that showed embedding RFID tags in student ID cards markedly enhanced accuracy and processing speed for attendance tracking. In another study, Ishaq and Bibi (2023) reported that RFID-based systems outperformed manual methods by reducing processing time, minimising human errors, and increasing reliability. Khan et al. (2022) combined RFID with programmable logic controllers and web apps to make automated real-time reporting possible. Other studies have shown that RFID makes monitoring environments safer and more accurate, reduces administrative work, and facilitates easier reporting (Mijić et al., 2019; Al-Naima & Ameen, 2021). Nonetheless, for RFID to be adopted, the design must meet the objectives and needs of the potential users.

Theoretical Framework

Diffusion of Innovation (DoI) theory

This theory was developed by Rogers in 1962 and expanded in 2003. The Theory explains how new ideas or technologies spread within a social system and why some innovations are adopted more readily than others. Rogers's DoI asserts that five factors influence whether someone will adopt a new innovation. They are relative advantage, compatibility, complexity, trialability, and observability. The RFID-based attendance systems are better than manual roll calls because they are more accurate, faster, and stop people from attending on behalf of others. It also meets the needs of institutions, such as the Nigerian University Commission's (NUC) 75% attendance policy, which makes them appealing to universities. According to

Rogers, adoption rates increase as technology becomes simpler to use. The easier it is to use RFID systems, the more likely lecturers and administrators are to embrace them. Trialability enables institutions to pilot RFID in selected departments before full implementation. While observability facilitates adoption by allowing stakeholders to clearly see the benefits, such as real-time reporting and reduced administrative burden.

Research Questions

The following research questions were raised to guide the study:

1. What are the objectives of an RFID-Based Student Attendance Management System (SAMS)?
2. What are the design and development requirements of an RFID-Based SAMS?

Methodology

Design of the Study

This study utilised a Research and Development (R&D) design, ideally suited for educational technology research aiming to integrate systematic inquiry with practical implementation. The R&D method enables researchers to identify problems in education, determine users' needs, and propose solutions that are effective in the real world. This R&D design was adopted to ascertain the objectives and requirements for developing a Radio Frequency Identification (RFID)-based Student Attendance Management System (SAMS) for higher education. The research specifically adhered to the initial stages of the R&D cycle, objectives assessment, and requirements analysis to establish a basis for the subsequent design and development of the system.

Population and Sample

The study was conducted at the University of Nigeria, Nsukka, which was chosen because it was well-equipped for technology and the administration needed a more effective way to track attendance. The study included 72 academic staff members, comprising 25 from the Department of Computer and Robotics Education and 47 from the Department of Electronics Engineering. These departments were purposively selected due to their members' technical proficiency and knowledge with microcontroller and RFID technologies, allowing them to offer informed feedback on system objectives and requirements.

The total population sampling technique was used, meaning all 72 faculty members participated in the study. However, only 46 participants successfully completed and returned the questionnaire. The total sampling was appropriate since the population of the study was small and manageable.

Instrumentation

The instrument for data collection was a self-developed structured questionnaire called the Radio Frequency Identification Needs Assessment Questionnaire (RFIDNAQ). This instrument was developed by the researcher through a review of related literature to elicit responses from respondents concerning the objectives and requirements of an RFID-based attendance management system. The RFIDNAQ consists of 20 questions, divided into two main parts: Part A covers demographic information. Part B addressed objectives (9 items) and technical requirements for developing an RFID-based attendance system (11 items). The items were rated on a four-point Likert scale thus: Strongly Agree = 4, Agree = 3, Disagree = 2 and Strongly Disagree = 1. The face and content validity of the instrument were determined by three experts, two from the Department of Computer and Robotics Education and one from the Department of Electronics Engineering. The reliability of the instrument was determined using Cronbach's alpha, which yielded a reliability coefficient of 0.875.

Method of Data Collection and Analysis

To collect data for this study, copies of the validated questionnaire were administered to the respondents with the help of two research assistants under the supervision of the principal researcher. Before submitting their completed questionnaires, respondents had sufficient time to consider their answers. For data analysis, the collated data were analysed using descriptive statistics (mean and standard deviation). A mean of 2.50 was set as the standard for decision-making. Items with mean ratings of 2.50 or higher were "accepted," as objectives or requirements for development of an RFID-based SAMS, while those with mean ratings below 2.50 were "rejected." This analytical method provided a structured approach to understanding what experts thought about the objectives and requirements of an RFID-based system for managing students' attendance.

Results

Table 1. Mean and Standard Deviation on Objectives of RFID-Based SAMS

S/N	Item Statements	N	\bar{x}	SD	Remark
1	Improving accuracy in recording student attendance.	46	3.85	0.36	Accepted
2	Enhancing efficiency in attendance tracking processes.	46	4.00	0.00	Accepted
3	Providing real-time monitoring of student attendance.	46	3.41	1.20	Accepted
4	Reducing administrative workload related to attendance.	46	3.63	0.49	Accepted
5	Enabling data-driven decision-making based on attendance trends.	46	3.48	0.51	Accepted
6	More paperwork leads to boredom	46	2.80	1.22	Accepted
7	Enhancing campus security through attendance verification.	46	3.09	1.19	Accepted
8	Facilitating integration with other university systems.	46	3.50	0.51	Accepted
9	Enhancing student engagement through improved attendance tracking	46	3.59	0.50	Accepted
Cluster1 Average		46	3.48	0.26	Accepted

The Results in Table 1 show that the respondents agreed with all the item statements as the objectives of the RFID-based students' attendance management system (SAMS). This is because their mean ratings

on the objectives of RFID-Based SAMS were above the criterion mean of 2.50. Also, the cluster mean of 3.48 ± 0.26 shows that they agreed with all the items as the objectives of RFID-Based SAMS.

Table 2. Mean and Standard Deviation on the Requirements for the Design and Development of RFID-Based SAMS

S/N	Item Statement	N	\bar{x}	SD	Remark
10	Considerations when choosing RFID tags for student identification. / Using RFID Tags for identification during the attendance process/ Placement of RFID tags on student IDs or badges.	46	3.83	0.38	Accepted
11	Strategic placement of RFID readers in key locations. / Using RFID Readers that communicate with the RFID tags and capture students' identification numbers	46	4.00	0.00	Accepted
12	Using RFID Middleware that captures the tag data from the readers, processes it, and sends it to the attendance management software or database	46	3.67	0.47	Accepted
13	Use of Arduino Uno for data collection and communication with RFID readers.	46	3.24	1.18	Accepted
14	Using RFID Antennas for emitting radio frequency signals and receiving responses from the RFID tags	46	3.87	0.34	Accepted
15	Development of the user interface for administrators and faculty.	46	4.00	0.00	Accepted
16	Using an attendance management software system to store and process the attendance data collected by the RFID system	46	3.85	0.36	Accepted
17	Using a robust network infrastructure to facilitate communication between the RFID readers, middleware, and attendance management software	46	3.48	0.51	Accepted
18	Securing the RFID system components, implementing security measures to protect student data and attendance records.	46	3.63	0.49	Accepted
19	Provision of proper training to staff and students who will be using or administering the RFID attendance system.	46	3.74	0.44	Accepted

20	Set of support channels for addressing user queries and issues.	46	3.72	0.46	Accepted
Cluster2 Average		46	3.73	0.16	Accepted

The Results in Table 2 show that the respondents agreed to all the item statements as the requirements for the design and development of an RFID-based students' attendance management system. This is because their mean ratings on the requirements for the design and development of RFID-Based SAMS were above the criterion mean of 2.50. Also, the cluster mean of 3.73 ± 0.16 shows that the respondents agreed to all the items as the requirements for the design and development of RFID-Based SAMS.

Discussion of Findings

The Objectives of RFID-Based SAMS

The results show that the respondents strongly agreed with all of the suggested objectives for an RFID-based Student Attendance Management System (SAMS). It was found that all experts agreed that this type of system is crucial for resolving the issues associated with manually tracking attendance. The objectives that received the highest ratings were improving the efficiency of attendance tracking systems and enhancing the accuracy of recording student attendance. The results further show that the respondents identified several objectives, including ease of integration with other university information systems, facilitating decision-making, and reducing the workload of administrators. This result shows that RFID-based systems are not only thought of as tools for improving attendance accuracy but also for making institutions more efficient and holding them accountable for their students' education.

A plausible explanation for these results is that respondents may have realised that the inefficiencies in the manual system create administrative problems for both academics and institutions, hence, the critical need for a dependable and automated system. Furthermore, according to the University Commission (NUC) guidelines, Nigerian examination eligibility requires a minimum of 75% attendance (Balogun et al., 2023). The RFID system could be a timely intervention in this context, considering the accuracy, timely nature and efficiency. This could be the plausible reason for experts' high ratings on objectives such as provision of real-time monitoring of student attendance and enhancing student engagement. This result is in agreement with previous studies, which show the revolutionary capabilities of RFID in the management of educational attendance. A study conducted by Ishaq and Bibi (2023) showed that an RFID-based attendance system made data more

accurate and cut down on the time it took to process attendance. Further studies have also shown that RFID technology eliminates the problems associated with traditional roll calls and enhances the services of organisations (Curtin et al., 2007; Jones et al., 2005). The present findings corroborate earlier research by emphasising that RFID is not solely a technical solution but an administrative innovation with extensive pedagogical advantages. In contrast to previous studies that concentrated solely on the technical dimensions of system design, the current research emphasises institutional and educational goals. This study supports DoI (Rogers, 2003) which asserts that the acceptance of any invention is predominantly influenced by its perceived relative advantage, compatibility, and observability.

Requirements for the Design and Development of RFID-Based SAMS

The result of this study with respect to the requirement for the design and development of RFID-Based SAMS, as presented in Table 2 showed that the participants agreed on all the requirements for the development of an RFID-based Student Attendance Management System (SAMS). Some of these are placing RFID readers in the correct places and designing interfaces that are straightforward for teachers and administrators to use. Other requirements included using RFID tags to identify students, middleware to analyse data, antennas, software to track attendance, and the need for training and support. This finding shows that an RFID-based system needs certain components to work, such as hardware, software, data security, and help for users. This finding is consistent with previous studies that demonstrate effective RFID systems require tags, readers, antennae, middleware, and backend software (Mabad, 2021). Haibi et al. (2023) confirmed similar results, emphasising the need for middleware and security measures to safeguard sensitive data. Another study by Alagos et al. (2025) argues that systems should have user-friendly interfaces to make them easier to utilise. When making the RFID-based SAM, you need also think about scalability, dependability, and technical support. (Mijić et al., 2019).

The Implications for Educational Policy

The results of this study are important for students, teachers, and schools. Implementing this approach could encourage students to attend class more

frequently, which should in turn improve their grades (Bugingo et al., 2025). This approach also gives teachers more time to lecture, as the manual attendance system consumes a significant amount of class time when there are a large number of students. An RFID-based system also enables administrators to easily track students who are in danger and provide them with assistance. It also helps individuals identify trends and make informed decisions based on facts, enabling them to utilise their resources more effectively. This would also help institutions run more smoothly by ensuring that quality assurance processes are improved and that records are stored accurately. The Nigerian University Commission (NUC), for instance, mandates that students must go to at least 75% of their classes in order to take examinations.

Conclusion

This study aimed to identify the objectives and needs for developing an RFID-based Student Attendance Management System (SAMS) in higher education. The study showed that an RFID-based system is superior to a manual-based system in accuracy, efficiency, reduction of paperwork, and real-time attendance monitoring. Also, RFID-based attendance management systems need reliable hardware and software, secure data management, easy-to-use interfaces, and complete training and support to perform successfully. These illustrate that the RFID-based technology can enable the Nigerian University Commission to maintain track of its rule that 75% minimum attendance must be attained by students to sit for examinations. It can also improve education overall by promoting accountability, involvement, and fact-based decision-making.

Recommendations

The following recommendations were made based on the results of this study:

1. The Ministry of Education should enforce a policy that supports the use RFID-based attendance systems instead of manual ones in all higher education institutions.
2. Software developers should combine RFID technologies with the university's current information systems so that data can be managed more easily.
3. Lecturers, administrators, and students should be given adequate training on how to use the system and also to enhance their confidence in using it.
4. The ICT units of universities should set up continuing technical support and monitoring methods to ensure that RFID attendance

systems are sustainable. Also, it should be trial tested in a few departments before rolling it out to the whole institution.

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