

# Awareness Analysis and Development of Low-Cost Smart Attendance Management System for Tertiary Institutions in Developing Countries

Jeremiah Tashie Wosu<sup>1</sup>, Elsie Chidinma Anderson<sup>2</sup>

<sup>1,2</sup>Department of Computer Engineering Technology, Port Harcourt Polytechnic, Rumuola, Port Harcourt, Nigeria

**Abstract**— With the advent of technology, the need for real time smart attendance processing has emerged as an essential pre-requisite for more efficient and accurate students attendance recording and management. The traditional method of attendance keeping which entails the use of pen and paper as well as calling names is time consuming and in most cases is associated with duplicate data entry, falsification/impersonation and errors. Conversely, smart attendance recording provides seamless services with reduced error and enhanced support needed in higher institutions for appropriate login/logout time of students. Thus, this research is focused on creating awareness about smart attendance management system (SAMS) based on data-driven smart technologies, as well as to develop a low-cost SAMS for higher institutions in developing countries with Nigeria as a case study. To this effect, an empirical survey using structured questionnaires was carried out in six tertiary institutions in Nigeria, and results of the statistical findings were synthesized with scientific tools for the design frame work. Moreover, the work built a prototype testbed to capture and disseminate the attendance of students in real time. The developed prototype comprises of Arduino Uno Microcontroller, Real time clock, Data logger shield, Radio Frequency Identification (RFID) card, Light Emitting Diodes (LEDs) and Switches. The Arduino microcontrollers were programmed using Arduino C programming language. The RFID smart attendance system was tested via status display device in real time (deterministic mode). A satisfactory result index of 99% was observed through various test case scenarios.

**Keywords**— Arduino Uno Microcontroller, Attendance recording, Awareness, Data-driven smart technologies, Data logger shield, Empirical survey, Prototype testbed, Radio Frequency Identification (RFID), Real time, Smart attendance management.

## I. INTRODUCTION

### A. Background Information

Smart attendance system comprises of both hardware and software tools that captures student daily attendance records and facilitates access to the attendance of a particular student in a particular class and also help in generating reports and evaluating the attendance eligibility of a student. Rather than signing an attendance sheet manually, the attendance records are captured electronically into a database which makes it easier and manageable [1]. It involves the use of data-driven smart technologies such as the sensors, LCD, Internet of things (IoT), RFID, microcontrollers, etc. [2].

Over the years, research has been taken into consideration in the various tertiary institutions in Nigeria for the purpose of enhancing academic excellence in the institutions [3]. According to [4], Attendance management has been a great challenge over the years in Nigerian academic institutions. Ranging from university to polytechnics, colleges of educations and secondary schools, quality attendance management has been a freak. A lot of factors have been attributed to the inefficient and decreased academic performance of students in the various institution of higher learning. These factors that have taken a firm place in student's lives include absenteeism, lateness, poor study habit, excessive use of mobile phones for entertainment and non-academic activities, etc. [5], [6]. An important aspect of this lapse is the records of attendance in terms of punctuality, regularity to duty and useful hours put to classes.

According to [7], poor attendance in class lecture is seen as one of the major reasons for student academic failure. Many

studies have revealed that students who attend classes on a regular basis are more likely to achieve higher grades than those students who have poor attendance. Hence, it can be said that attendance is one of the most important criteria for the recording and assessment of the performance of student in an institution of higher learning.

The problem of student poor attendance to lectures is still one of the major issues encountered by most lectures in institution of higher learning today. Many colleges and universities have compulsory attendance policies while others have refrain from making it mandatory. Despite the different policies, higher institution educators believe that an above average attendance would have a positive effect on the increased academic performance of a student [8].

Presently, the obtainable approach for attendance taking in many institutions in Nigeria, if not all, is the paper-based (i.e. signing of attendance sheet or calling names). This method has proven to have some associated problems such as time wastage, fake attendance, misplacement/damage of attendance sheet and high error, thus making the system inefficient and ineffective. Moreover, the paper attendance sheet may get missing due to human deficiencies [9]. Hence, there is an exigent need for a better approach to effectively automate and monitor students' attendance. Even though some systems have been designed to tackle these challenges as highlighted earlier, the practical implementation of such systems in institutions in developing countries such as Nigeria, could be challenging and unrealistic due to high monetary cost, awareness factor, the need to deploy specialized hardware as well as the susceptibility to fake or proxy attendance.

### B. Research Objectives

The aim of this research is to create awareness about smart attendance management system (SAMS) based on data-driven smart technologies, as well as to develop a low-cost SAMS for higher institutions in developing countries. The objectives are as follows;

1. To carry out empirical survey using structured questionnaires in six tertiary institutions in Nigeria.
2. To synthesize results of the statistical findings with scientific tools for the design frame work.
3. To build a prototype system to capture and disseminate the attendance of students in real time.
4. To test the developed system in order to evaluate its performance.

The remainder of this research is structured as follows; Section II reviews works related to design and implementation of SAMS, Section III presents the awareness analysis on SAMS, Section IV presents the architectural design of the system, Section V presents and discusses results that were obtained, and finally, the research is drawn to a conclusion in section VI.

## II. REVIEW OF RELATED LITERATURES

### A. Review of Related Works on SAMS

Numerous works that involves the use of data-driven smart technologies such as RFID, fingerprint scanner, barcode reader, camera, android app and GSM module smart attendance system exist. A review of some recent studies is presented in this section.

The growing trend of smart attendance system calls for its incorporation into the various Nigerian tertiary institutions with the sole aim of enhancing academic excellence. The work in [5] examined the existing system by carrying out a survey analysis using interviews, observation and document analysis. From the result of the analysis, the existing system is termed inefficient, encourages absenteeism, faces difficulty in updating record and manually calculating the percentage of classes attended, hence the system was judged not good for the management of attendance record.

According to [10], discovering the issues that define academic performance is an integral part of educational research. The authors based their findings on the use of survey and self-report, methods which have well-known systematic biases that lead to limitations on conclusions and generalizability as well as being costly to implement. They also proposed a novel method for measuring class attendance that overcomes these limitations by using location and Bluetooth data collected from Smartphone sensors. The result of their findings demonstrated clearly that early and consistent class attendance strongly correlates with academic performance.

The authors [11] focused on identifying practical advantages for reducing errors encountered in the conventional attendance system. Different methods such as survey and interview were adopted to conduct a direct interview with institutions and academics to obtain relevant information used in the design of the new android-based student attendance system was able to track student's

performance and provide prior intimacy when attendance is below threshold in the form of SMS.

[12] conducted a determinant study of students' academic performance with relationship to class attendance using the Statistical Package for Social Sciences (SPSS) 17.0 to present the descriptive and inferential statistics. The author also considered the moderating effect of gender on attendance and academic performance. The results of the investigation revealed a significant effect of attendance marks on academic scores at  $p < 0.05$  ( $t = 0.00$ ). However there was no significant effect of gender on academic scores ( $t = 0.484$ ),  $p < 0.005$  and also, no significant effect of gender on attendance ( $t = 0.986$ ) at  $p < 0.05$ .

The authors in [13] in other to eliminate issues encountered in the traditional attendance system developed an automated attendance management system using biometric face detection. The work made use of digital image capturing devices to capture the faces of students present in the class which serves as the attendance. The designed system effectively addressed the issues of impersonation and falsification but did not consider time wastage/consumption which is a major issue in the existing system.

The work in [14] proposed a smart attendance management system using a combination of both biometric feature and GSM module. The fingerprint module was used to capture students attendance at real time, while the GSM module was used to send the attendance of students to the guidance as SMS. They also used alarm system which is been triggered in the eventuality of a mismatched fingerprint captured when compared with the one stored in the system's database. The scope of the system was limited to getting accurate student attendance but did not put into consideration the cost of deployment as well as time wastage in capturing students fingerprint.

Authors in [15] developed an automated attendance system that authenticates students based on username and password via the use of android application installed on android phones. The designed system could not eliminate issues of falsification and impersonation encountered in the existing system since the user name and password can be shared or meddled with. Also there is the possibility of forgotten password and students without android phones may have difficulties attaining the required attendance mark.

An embedded smart attendance management system using barcode reader was proposed by [16]. The system was developed to help provide valuable information about students' attendance report at real time as well as help in generating defaulters lists on its own and send emails to students whose attendance is below the minimum requirement goal. The system addressed issues of attendance encountered in existing system but is not cost effective and cannot be deployed in most institution.

### B. Research Gaps

Thus far, considering the related literatures reviewed, the following research gaps have been identified as regards the application of inexpensive materials in the development of smart attendance management system;

1. None of the research was focused on under-developed or developing societies where the standard of living is very low, and finances required to implement smart attendance management system with expensive materials may not be available.
2. Attention was not actually given to the utilisation of awareness analysis for the development of SAMS.

### C. Research Contribution

This work proposes to create awareness of smart attendance management system (SAMS) in Nigerian tertiary institutions as well as to develop a low-cost SAMS based on data-driven smart technologies for higher institutions in developing countries. Its benefits are aimed at eliminating duplicate data entry, falsification/impersonation and errors encountered in the manual attendance systems; thereby enhancing students' academic performance.

This is achieved by carrying out empirical survey using structured questionnaires in six tertiary institutions in Nigeria, and results of the statistical findings were synthesized with scientific tools for the design frame work. Moreover, the work develops prototype using Arduino Uno Microcontroller, Real time clock, Data logger shield, Radio Frequency Identification (RFID) card, Light Emitting Diodes (LEDs) and Switches. The Arduino microcontrollers were programmed using Arduino C programming language. All of these account for affordable and easy implementation of a reliable low-cost SAMS.

### III. SMAS PARAMETRIC SURVEY AND ANALYSIS

A parametric survey is a systematic method for gathering information from a sample of individuals for the purpose of describing the attributes of the larger population of which the individuals are members. In the context of this research, empirical survey using structured questionnaires (as shown in the Appendix) was carried out in six tertiary institutions in Rivers State of Nigeria, and results of statistical findings were synthesized with scientific tools for the design frame work.

The empirical survey was carried out to create awareness about SAMS in tertiary institutions. How the system could be implemented within a sample population was also investigated. The first step applied was to find out issues that are peculiar to users (staff of tertiary institutions) when trying to take attendance of students. In this work also, effort was made to find out whether individual staff are willing to embrace the new technology of SAMS.

#### A. Measuring Instruments

Method of data analysis was done using descriptive statistics and parametric statistics (T-test and ANOVA) to ascertain the perception of participants on SAMS, and all analysis were carried out using SPSS 20.

#### B. Experimental Measurements

Data gathering techniques such as questionnaires and observations were used in the data collection process in order to collect quantitative and qualitative information essential for designing the required specification for the new SAMS system.

Table 1 is made up of an organized survey questionnaire with multi-stage sampling which contained 13 item questions given to the respondents. Column two represents number of options to answer each question, column three consists of the number of respondents to a particular question while columns four and five are made up of the minimum number of responses to a question and maximum number of responses to each question in the questionnaire respectively.

The sample populations varied from male to female whose educational qualification varied from O'level or its equivalent to PhD. Young adults as well as aged people with varied income groups were included. With the multi-stage survey, the populace was educated on SAMS and its benefits when adopted in Nigerian context. Results of the statistical findings were synthesized with scientific tools for the design frame work. Table 1 displays the frequency distribution table congregated from the questionnaire.

TABLE 1: Descriptive Statistics of the Questionnaires

Questions from the questionnaires	Number of options to answer each question	Number of Respon-dents	Min. no. of Ans. to each ques.	Max. no. of Ans. to each ques.
What is the name of your organization?	6	80	1	6
What is your educational qualification?	6	78	1	6
Number of years of working experience	2	59	1	2
Are you aware of smart attendance management system?	3	79	1	3
Would you like to move from manual attendance to smart attendance system?	4	79	1	4
What issue do you face the most in the manual/ traditional method of recording attendance?	5	80	1	5
How long does it take to sign into the class?	7	78	1	7
Would you consent to the use of various technologies (RFID card, LCD, etc.) to tackle problem of attendance falsification and impersonation?	4	78	1	4
What would likely be the cause of poor student academic performance?	5	80	1	5
Do you think that the smart attendance system would result in improved student performance?	3	80	1	3
Do you think any security measure is been provided to avoid falsification and impersonation of student attendance?	3	80	1	3
Would you consent to the use of security measures to checkmate the attendance management system?	4	80	1	4
Do you think it is necessary to improve on our existing manual attendance system to smart attendance system?	3	80	1	3

### C. Data Collections

Data collections were made through selected institutions viz: University of Port Harcourt, Rivers State University, Ignatius Ajuru University of Education, Rivers State College of Health, Ken Saro-Wiwa Polytechnic and Port Harcourt Polytechnic; all in Rivers State, Nigeria as shown in Table 2 where attendance issues have actually posed a major challenge. Individuals from these institutions constituted the sample space. The table also consisted of the number of respondents to a particular institution, the percentage and valid percentage of respondents in an institution.

TABLE 2: Name of your organization

S/N	Name of School	Frequency	Percent	Valid percent	Cumulative
1	University of Port Harcourt	25	31.2	31.2	31.2
2	Rivers State University	10	12.5	12.5	43.7
3	Ignatius Ajuru University of Education	15	18.8	18.8	62.5
4	Rivers State College of Health	10	12.5	12.5	75
5	Ken Saro-Wiwa Polytechnic	10	12.5	12.5	87.5
6	Port Harcourt Polytechnic	10	12.5	12.5	100
	<b>TOTAL</b>	<b>80</b>	<b>100.0</b>	<b>100.0</b>	

From Table 2, out of a total of 80 (100%) participants, 25 (31.2%) are staff of University of Port Harcourt, 10 (12.5%) work with Rivers State University, 15 (18.8%) are staff of Ignatius Ajuru University of Education, 10 (12.5%) work with Rivers State College of Health, 10 (12.5%) are staff of Ken Saro-Wiwa Polytechnic while 10 (12.5%) worked with Port Harcourt Polytechnic.

### D. Educational Qualification

Table 3 displays the educational qualification of the respondents which includes O' level or its equivalent, NCE or its equivalent, B.Sc or its equivalent, PGD/M.Sc/M.Eng or its equivalent and PhD. The table also consists of the number of respondents to a particular educational qualification, the percentage of each qualification and valid percentage of respondents to a qualification.

TABLE 3: Educational qualification

S/N	Educational Qualification	Frequency	Percent	Valid percent
1	O' level or its equivalent	13	16.3	16.7
2	NCE or its equivalent	15	18.8	19.2
3	B.Sc or its equivalent	12	15.0	15.4
4	PGD/M.Sc/ M.Eng or its equivalent	22	27.5	28.2
5	PhD	16	20.0	20.5
6	No Response	2	2.5	
	<b>TOTAL</b>	<b>80</b>	<b>100.0</b>	<b>100.0</b>

### E. Working Experience

Table 4 displays the number of years of working experience in an organization, the number of respondents, the percentage and valid percentage of respondents with regards to working experience in an organization.

TABLE 4: Number of years of working experience

S/N	Year Range	Frequency	Percent	Valid percent	Cummulative Percent
1	Below 5 years	22	27.5	37.3	37.3
2	Above 5 years	37	46.3	62.7	100
3	No response	21	26.2		
	<b>TOTAL</b>	<b>80</b>	<b>100.0</b>	<b>100.0</b>	

### F. Awareness of SAMS

Table 5 displays the response of the populace on awareness of Smart Attendance system. The table also consisted of the no of respondents, percentage and valid percentage of respondents to the question on the awareness of SAMS.

TABLE 5: Awareness of SAMS

S/N	Response	Frequency	Percent	Valid percent
1	Yes	20	25.0	25.3
2	No	59	73.8	74.7
3	No response	1	1.2	
	<b>TOTAL</b>	<b>80</b>	<b>100.0</b>	<b>100.0</b>

From Table 5 out of 80 questionnaire distributed to participants, 79 (98.8%) responded while 1 (1.3%) did not respond to either of the options. From the analysis 20 (25.0%) are aware of SAMS while 59 (73.8) are not aware of it.

## IV. DESIGN FRAMEWORK/ARCHITECTURE

The smart attendance management system consists of both hardware and software used to drive the system. The hardware comprises of the following components, an Arduino Uno Microcontroller, which coordinates the activities of the smart attendance management system. It also processes data collected from the RFID module and real-time clock, and give output through the LCD Screen as well as memory card connected to the SD data logger, RFID Card is used by the student to get their attendance done at real time, RFID Module which reads the RFID card, a Real Time Clock (RTC) used to get the accurate time and date of student attendance, SD Data Logger used to save the status of student attendance gotten from the Arduino Uno microcontroller, and Liquid Crystal Display (LCD) which displays the current state of successful/unsuccessful student attendance as shown in Figure 1. The software used is written in Arduino programming language, which is uploaded to the Arduino microcontroller.

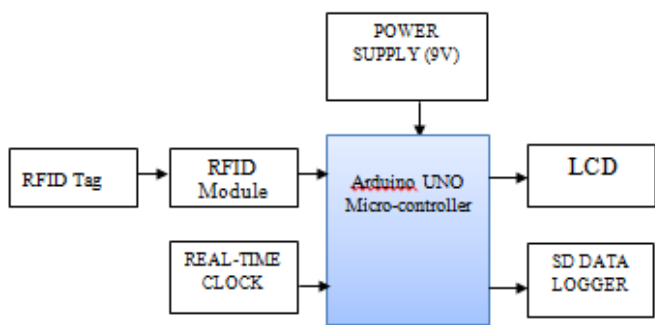


Fig. 1. Block Diagram of the Smart Attendance System

(A) Schematic Diagram

The schematic diagram of the proposed system is as shown in Figure 2 below;

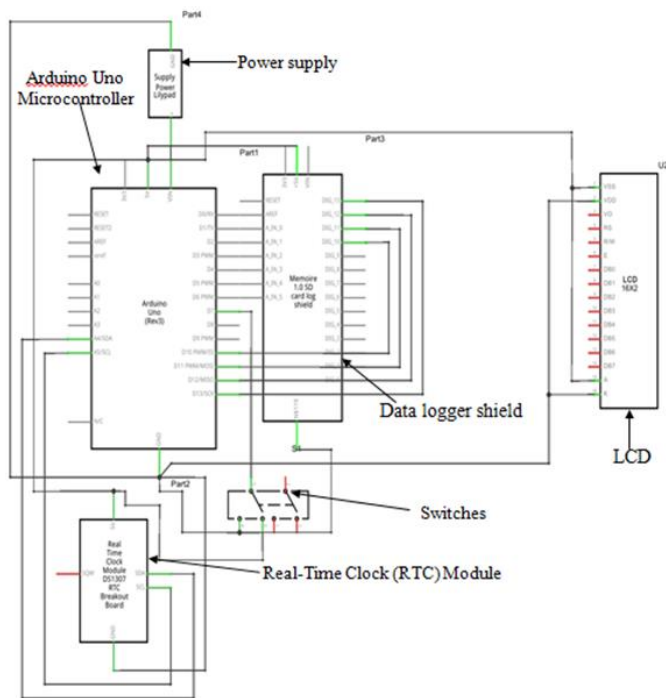


Fig. 2. Schematic Diagram of the System

In the diagram above, the 9 volts battery is connected to the Arduino Uno using a power cable, sensors are then attached to the system. The RTC and Data Logger are plugged directly on the microcontroller since it's a shield, not a module or chip. The LCD is connected to the Arduino using an I2c driver which is used to reduce the amount of connecting wires used from 12 to just four by taking advantage of the I2c communication protocol. The RFID is then connected to the controller using the SPI communication pins except pin 10 which is already in use by the data logger as a chip select pin. The buttons and switches are also connected to the Arduino easy control.

Whenever the RFID senses a new card it simply reads the card's UID and identifies the owner of the card. If valid, the system record the name of the owner of the card in the system (SD data logger) and then also record the date and time from the RTC on the shield and indicates if the action was

successful or not in the contrary, which is displayed on the LCD screen to the keep user informed on the current state of the system.

(B) Algorithm

The algorithm of how the proposed system works/functions are shown below;

1. Start
2. Initialize input and output pins
3. Is the new file created?
4. If No
5. Return to Initialization
6. If Yes
7. Place a card to read
8. Is the card read and valid?
9. If No
10. Return to place a card to read
11. If Yes
12. Store card name, date and time
13. End

(C) Flowchart

The flow chart of the designed system is as shown in Figure 3 below.

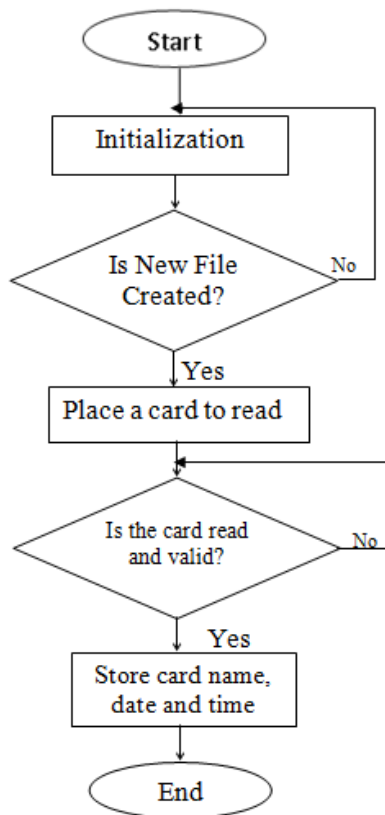


Fig. 3. Flow Chart of the System

(D) Prototype System

The complete system as shown in Figure 4 comprises of a 9 volts battery connected to the Arduino Uno using a power cable, the sensors are attached to the system. The RTC and Data Logger are plugged directly to the microcontroller since

it's a shield, not a module or chip. The LCD is connected to the Arduino using a I2c driver which is used to reduce the amount of connecting wires used from 12 to just four by taking advantage of the I2c communication protocol. The RFID module is connected to the controller using the SPI communication pins except pin 10 which is already in use by the data logger as a chip select pin. The buttons and switches are also connected to the Arduino easy control.

Whenever the RFID senses a new card it simply reads the card's UID and identifies the owner of the card. If valid, the system record the name of the owner of the card in the system (SD data logger) and then also record the date and time from the RTC on the shield and indicates if the action was successful or nothing on the contrary, which is displayed on the LCD screen to the keep user informed on the current state of the system.



Fig. 6. LCD Displaying attendance status of a student

After implementing the prototype system, the performance of the system was tested for accuracy and speed of execution. Accuracy in this case simply implies the tendency of the system to detect and accept only genuine RFID cards, while speed of execution simply means the time taken for the system to process an RFID card and output whether it is genuine or not. Five different RFID cards were used in testing the system, and results obtained are sampled in Table 6 below.

TABLE 6: RFID Card detection and Speed of Execution of a SAMS Prototype

S/N	RFID Card Detection	Time of Execution (ms)
1.	Accurate	15.9
2.	Accurate	17.0
3.	Accurate	16.6
4.	Accurate	16.4
5.	Accurate	16.6
	<b>Average</b>	<b>16.5</b>

From the table above, it could be seen that the time of execution of the system ranges from 15.9 to 17.0 milliseconds. Thus, the average time of execution is 16.5 milliseconds for the five tests. Moreover, the accuracy of detection for the system is about 100%.

## VI. CONCLUSION

This paper has created awareness and presented disruptive ideas on smart attendance system within the context of developing countries. An empirical survey using structured questionnaires was carried out, and results of the statistical findings were synthesized with scientific tools for the design frame work. It made use of various low cost, low error and very high efficient RFID card and RFID module to capture student attendance in real time, hence providing a robust and reliable system. The work employed Real time clock to get the time and date of student entry into the class and an LCD which displays the status of student attendance. The functionality of the various components offers numerous advantages and flexibilities in the educational sector since attendance can be accurately taken void of falsification, impersonation and time wastage. No doubt, this work will contribute immensely to students' academic performance.

## APPENDIX

### SURVEY QUESTIONNAIRE WITH SAMS

#### Letter to Respondents

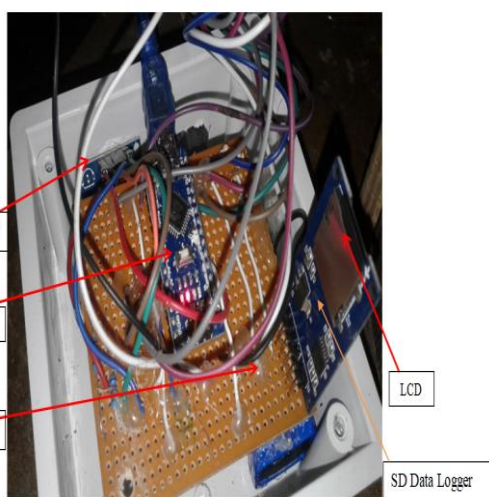


Fig. 4. Complete Smart Attendance System

## V. RESULTS AND DISCUSSIONS

A simple picture of when the system is up and ready to read an RFID tag and when the system has already taken an attendance is shown in Figure 5 and Figure 6 respectively below.



Fig. 5. System is ready to read the RFID card

Dear Respondent,

This is a survey template designed to collect data on **Smart Attendance System in relation to Attendance System in Tertiary/Organizations in Nigeria**. The view is that you can contribute immensely to the success of the research work through your response to all the items of the questionnaire, which will be treated in strict confidence and purely for technological advancement. Do please, respond to each item freely as you consider it fit for the point addressed.

Thanks for your cooperation.

**Researcher**

**SECTION A**

Please fill in or tick (✓) the correct response to each of the following items as it applies to you.

- i. Name:.....
- ii. Institution:.....
- iii. Department:.....
- iv. Educational qualification:
  - SSCE or its equivalent
  - NCE or its equivalent
  - B. Sc. or its equivalent
  - M. Sc./PGD or the equivalent
  - PhD
  - No Response
- v. Number of years of working experience:
  - Below 5 Years
  - Above 5 Years
  - No Response

**SECTION B**

- 1. Are you aware of smart attendance management system?
  - a) Yes
  - b) No
  - c) No Response

If yes, how did you get to know about it? .....

- 2. Would you like to move from manual/traditional attendance to smart attendance system?
  - a) Strongly Agree
  - b) Agree
  - c) Disagree
  - d) Strongly Disagree
- 3. What issue do you face the most in the manual/traditional attendance system?
  - a) Time consumption
  - b) Misplaced list
  - c) Impersonation/falsification
  - d) Security concern
  - e) Others (please specify).....
- 4. How long does it take to sign into the class? .....
- 5. Would you consent to the use of various technologies (RFID card, LCD, etc.) to tackle problem of falsification/impersonation?
  - a) Strongly Agree
  - b) Agree
  - c) Disagree
  - d) Strongly Disagree
- 6. What would likely be the cause of poor student academic performance? .....
- 7. Do you think that the smart attendance system would result in improved student performance?
  - a) Yes
  - b) No
  - c) No Response
- 8. Do you think any security measure is been provided to avoid falsification and impersonation?
  - a) Yes
  - b) No
  - c) No Response

If yes explain? .....

9. Would you consent to the use of security measure to checkmate the attendance system?

- a) Strongly Agree
- b) Agree
- c) Disagree
- d) Strongly Disagree

10. Is it necessary to improve on our existing attendance system to smart attendance system?

- a) Yes
- b) No
- c) No Response

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