NFC Framework for Monitoring Student's Classroom Performance and a Door Lock System with UPS via IOT Application

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***Abstract*---- Traditional or paper-based student classroom performance assessments are prone to loss, time-consuming, lack of security, cost-inefficient, and a lot of editing challenges. These reasons prove to be a challenging task and struggle for both instructors, professors and for students. Globally, competent educational institutions implement a systematic way of effective student assessment and monitoring with the help of diverse and rapid development of technology over the millennia. Near-Field Communication is one of the leading technologies used nowadays especially for ease, a secure and faster way that was mostly applied on smart cards, e-wallet, smart ticketing, in the field of medicine and healthcare, keyless access, smart inventory management, and burglar control and many more applications. These are the key reasons why NFC technology combined with a Fingerprint scanning technology integrated into a door lock system as an innovative solution for the present problems concerning record-keeping of students' academic performance and classroom security. Also, the Internet of Things (IoT) takes a major role in keeping data in cloud storage so that, the information was accessible anytime using a developed mobile application.**

***Keywords*---- Near Field Communication (NFC), Internet of Things (IoT), Time Attendance Management System (TAMS).**

I. INTRODUCTION

Traditional way of recording students' classroom performance is paper-based assessments often does not allow for the customization of questions, standard reports are often used without the ability to present results differently, whether showing results over time or across multiple courses. In 2013, As Department of Education 7300 public school students lost their school records due to super typhoon Yolanda in Eastern Visayas [1]. As traditional way merge into present of 'recording students' classroom performance data is prone to loss, time consuming, lack of security, cost inefficient, and lot of editing challenges. Manually monitoring of students' academic performance and behavior is a challenging task for instructors and facilitators. Collecting, sorting and organizing of these data is a cumbersome task, especially when it is done manually which affects its integrity [2].

Nowadays, computer is efficient to use great ease and flexibility to the creation and editing of documents in many countries. It is widely used for its versatility, as a result it is called the Computer Based. It could end up into many uses such as all components necessary to capture, process, transfer, store, display, and manage information. One of its uses is for collecting for systems in educational institutions. As technology rises, Digitalization take places and leads to the world of automation. Digital records is a solution which mitigate risk like students' file losses and data entry errors that can help both instructors and students to make the process paperless, secure and efficient [3].

Mostly, experienced instructors and faculties classifies them through vision inspecting that could be very hard for individual person. For that, using database and IoT was done. This proposed research focuses on determination of tracking records ensuring accurate and reliable information collection for systems in educational institutions through its upgraded technologies.

II. RELATED LITERATURE

To develop NFC Framework for Monitoring Student's Classroom Performance and a Door Lock System with UPS via IoT Application, the researchers worked and studied from different perspectives.

Thailand University conducted a study about attendance system developed using NFC Technology. The created system works with a one host server which is connected and access by instructors' NFC enabled mobile

phone also the camera device is used for recording the attendance of oneself with respect to their identity to prevent proxy. The system developed by implementing Java as Android operating system's programming language, SQLite for mobile data storage, evaluation of the created application using Samsung Galaxy Note3 and MySQL for data storage on the server. Based on the overall system evaluation the proponents conclude that the system is flexible, the used algorithm obtains a reliable and stable results, and the demonstration of NFC technology-based system are well executed [4].

On the other hand, NFC is used as controller to access the door lock system, which it takes a lead role in executing authentication and access of a classroom by the authorized personnel. By the used of best type of tags such as type 2, NXP 215 and NXP 216 which are sensitive and suitable of 5-6 cm range that is needed for the application. This project uses an integration of Arduino IDE, Python and MySQL for structuring the software. In conducting the authentication accuracy test the researchers obtained a 100% accuracy in recognition and authorization of the NFC card. Also, this study highlighted the used of sub-circuit breaker for conservation of energy and managing the device's power supply [5]. As a same principle, a previous study used NFC in executing Data Exchange Format for software design and its main feature to access in a door lock system by means of logical link control protocol (LLCP). The access control system is built using microcontrollers (MCU) magnetic lock, status indication, real-time clock module and NFC reader module as main components. The main features of the system offer a tri-modal selective method for door locking and unlocking by the used of developed smartphone application [6].

Due to wide range application of Internet of things and its capability to build a network infrastructure that can integrate and control physical environment a study about Attendance Management is conducted. This study highlighted the implementation of Internet of Things through Raspberry Pi 3 and RFID Technology allowing the automation of traditional way of daily attendance recording which is time and energy consuming. This proposed system operation which have two phases: registration and recognition. The registration phase is the process which the data of students are collected and fed into computers memory with respect to the RFID. However, the recognition phase is the process in which the students' stored data recognized and recorded in concerned faculty's database done by integrated IoT and Raspberry Pi3.

The proposed system is capable to operate in extended to more data collection for big number of students and classes with database generation and update. The proponents conclude that the developed system is secure, reliable, fast and efficient by evaluation the functionality of the system itself [7].

. On the other hand, Internet of Things is used for attendance monitoring integrated to non-biometric identification. This system can be served as a recording student attendance tool. It also offers the history in a time efficient and digitalized manner where the students' personal data is more secure. The main challenge was to identify a single person without using any bio-metric sensors. So, the proponents come up with the used of unique factor, the W-H Fusion function in the proposed system. Load cell, ultrasonic sensor and RFID reader are the necessary components used for collection of students' individual's data. Also, as Iot device cloud database is used for storing the sensor's input that is connected to the Raspberry Pi. Firebase is a cloud databased used for the cloud update which is implemented with REST API that maintains the MQTT protocol of IOT.

The proposed system used load sensor in a platform where the student's name, height, and weight are collected and stored to the RFID as Non-Biometric Identification. The W-H function is capable to identify individual student accurately unless different students have same height and weight measurement. Its performance evaluation obtained that it can perfectly detect class enter time, exit time and any kind proxy. In case that the system has proxy detection the LCD display indicate and show the case and triggers the alarm [8]. These said researches inspires the proponents to develop a system by integrating class record and attendance system to classroom door lock.

III. METHODOLOGY

A. Hardware Developments

The main idea of this project study is to create a system where the smart door lock, attendance taking, class record keeping, and viewing of grades is integrated in to one by the help of NFC and IoT. The Input-Process-Output of the project study and its Block Diagram are shown below.

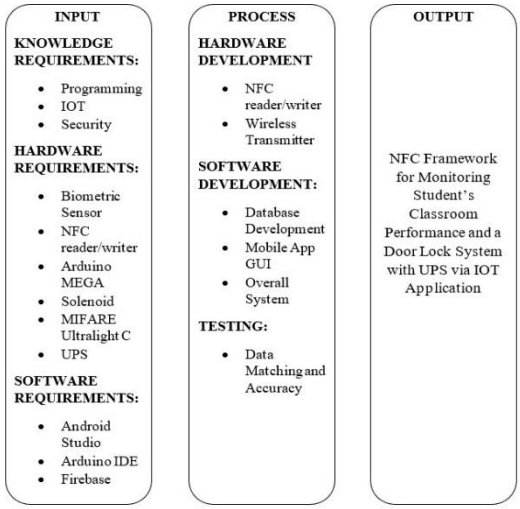

Fig. 1. The input, process, and output of the project

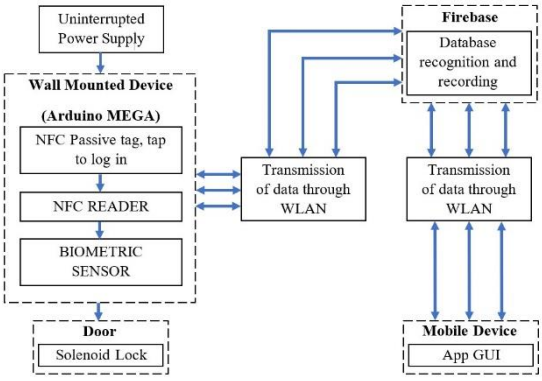

Fig. 2. The block diagram of the system.

To develop the NFC framework for the secure door lock system, performance monitoring, and the database, having proper knowledge, hardware, and software requirements are needed as shown in Figure 1 to start the research. The software requirement is mainly for Arduino IDE, Firebase, and Android Studio. The hardware requirements are composed of the following; MIFARE Ultralight® C, NFC Reader Writer, a biometric sensor, a solenoid door lock, and an uninterrupted power supply. The Arduino MEGA is necessary as it will act as the processor of the whole system.

The process block contains the development of the hardware that is connected to a cloud server. The programming for the database will be developed using the Google Firebase, while for the GUI of the mobile application is by Android Studio. The output of the system will be the NFC Framework for Monitoring Student's Classroom Performance and a Door Lock System with Uninterruptable Power Supply via IoT Application.

To further explain the IPO, this section shows the block diagram, the system is composed of three main sections. The first section is the system that is mounted to the wall, this part will be the area where the attendance checking happens. Also, it is a system connected to a solenoid door lock which is activated by tapping an NFC card to the reader/writer, as an additional security a fingerprint is also needed. The second system is the part where the professor can record the students' classroom performance by importing an xls file using the mobile application provided. Students can also use this mobile application where they can see their personal class records. The last part is where all the data is collected and accessed, using Google Firebase.

i. Hardware Structure

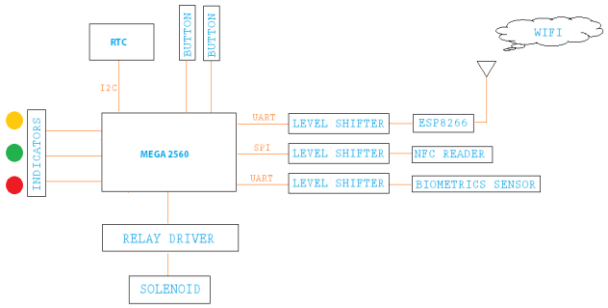

Fig. 3. The block diagram of the components used.

The block diagram shows the components used and how it's connected to each other. The following are the materials that will be used for the overall system of the project study.

i. Arduino MEGA 2560

The study uses the Arduino MEGA 2560 module, because it can execute powerful instruction in a single clock cycle, it has a fine balance between power consumption and processing speed. It will act as the central control of the processing of data and information of the system.

ii. NFC Tag/Reader

In this project study, the researchers thoroughly selected the most suitable NFC Tag/Reader that will be used for the data transfer; this is achieved through research and experimentation of the components.

For the NFC Reader, the researchers tested different NFC reader that is available at the market and ended up with the NFC PN522 Breakout Board. It's the most compatible with the central processing unit that we chose, and it's also widely used NFC chip in project prototyping. While the NFC tags were chosen based on past established studies.

iii. GT-521F32 Fingerprint Module

The researchers used this fingerprint scanner because it can be easily embedded into the project. The module itself does all the heavy lifting behind the reading and identifying the fingerprints with an onboard optical sensor and 32-bit ARM Cortex M3 processor

iv. NodeMCU ESP8266

The researchers needed a microcontroller that can communicate between Arduino Mega and the

Firebase SDK because the project study is an IoT device and the data are in a cloud storage.

v. Solenoid

The researcher used a 12V solenoid lock because it is compatible to the Arduino Mega with just an added relay.

vi. WLAN Repeater

Since the project study is an IoT, the need for a WLAN Repeater has different uses; it would extend the range of the signal, communicating to the other devices, and lastly it will send the data that the device collected to a cloud storage for later use.

vii. Enclosure

The chassis of the project study is an enclosure made up of Acrylonitrile Butadiene Styrene (ABS) with a rating of NEMA 4 which makes it essentially a weatherproof casing.

viii. DS3231 RTC

Because the device collects attendance and send it to cloud storage, a high precision real-time clock module is needed as it maintains the synchronization of all the device of the project study.

B. *Software Development*

i. Programming Language

The proponents used four different programming language in this study; Arduino IDE is used for the ARDUINO MEGA which controls the door lock and integrate the whole system, while Android Studio is used for the GUI of the mobile application, for the database--- JavaScript has been used for Firebase SDK.

ii. Software Structure

The three major flowchart of the whole system is shown below:

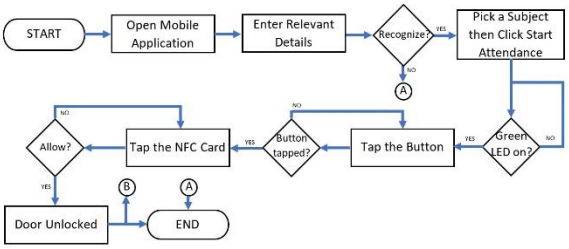

Fig. 4. The first flowchart of the system

At the beginning, the professor needs to open the mobile application and enter the necessary details required to begin the process; if the details entered are correct it then can proceed, if not, then just retry and input the correct information. In the proceeding block, after the authorization has been validated, the professor needs to select the subject that they want to collect the attendance for, when the green LED is on, the professor can proceed by tapping the button on the device, and after that they can then tapped their NFC card; if the card that is detected is authorized, the automated door lock will unlock, if not then just tapped the correct NFC card.

Fig. 5. The second flowchart of the system

After the professor, the students can then now start the attendance by; if the green LED is on, they need to tap their NFC card and wait for several seconds for the fingerprint scanner to light up and scan their finger. They can then enter the classroom just by that.

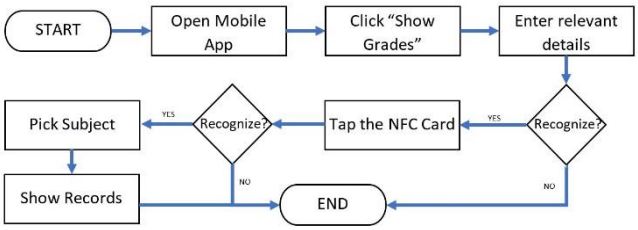

Fig. 6. The third flowchart of the system

If the students wish to view their scores or records, they need to open the mobile application and click the text 'Show Grades', entering the credentials needed, if the database recognize then proceed to tapping the NFC Card in the device near the door, if not then the process will end. In the proceeding block, after the authorization has been complete, pick the subject that want the data to be shown and by exiting the mobile application, the process will end.

C. *Testing Procedure*

Before testing the whole program for the NFC Framework, the researcher needs to test which NFC reader/writer were the most suitable for usage. The NFC reader were tested by its detection distance with the MIFARE Ultralight C card. Since Arduino MEGA is being used as the microcontroller, convenience of use in integrating the NFC reader/writer is also being considered for programming.

i. Testing the NFC Reader/Writer

The testing will be done to determine which NFC Reader/Writer is the most compatible with the Arduino MEGA microcontroller.

ii. Database Testing

The database stores the data coming from the ESP8266 client. Each classroom assigned will have its own client. The researcher will test its ability to communicate to the system.

iii. GUI Testing

The researcher will test the mobile application if the interface is user friendly. The group will also test whether it will successfully communicate with the database.

IV. RESULTS AND DISCUSSION

A. Hardware Results

i. NFC Controlled Door Lock Prototype

The front view of the device is shown; the function of its parts is also included.

a. Front View

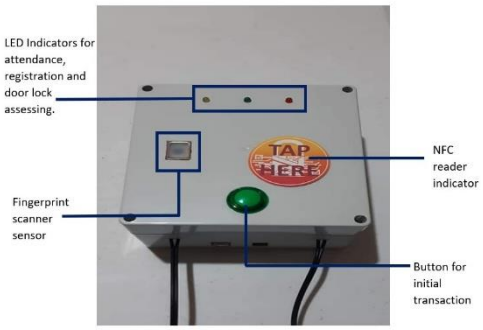

Fig. 7. The front view of the parts with label

1. LED Indicator – There are three indicator LEDs that had different color and different function base on status feedback of the device such as:
    a. Yellow – Indicates that the device is on ready state to access.
    b. Green – Indicates that there is an ongoing class on the certain classroom
    c. Red – Indicates that the registration for a subject or attendance failed; also, after a successful attendance slot the red button lighted up in a mean of a seconds, meaning the recent slot was in overwrite state.
2. Initial Transaction Button – It is a lamp push button that lights up when the door lock successfully access, also it is used to opening a slot for attendance of every students.
3. Fingerprint scanner sensor – Biometric input requirement to authenticate every user's identification of security purposes.
4. NFC Reader Indicator – A sticker which the NFC reader was placed below; also, one of input requirement to access the door lock device.

b. Internal of the Device

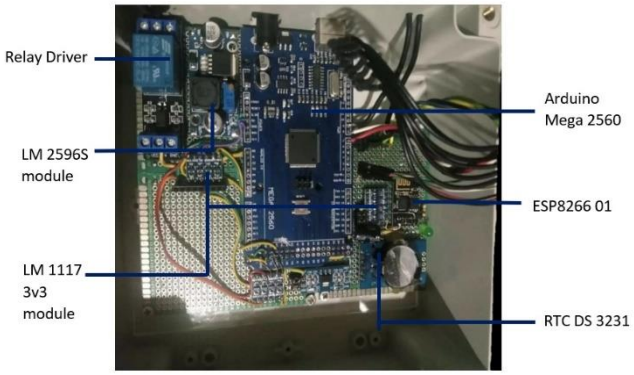

Fig. 8. Central Processing Unit

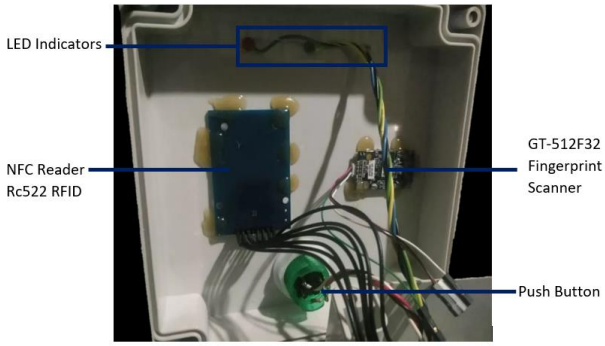

Fig. 9. Sensor and Indicators

1. Relay Driver – Used as switch to unlock the solenoid lock when an electronic signal from the sensors granted by the specific requirements.
2. LM 2596S module – Voltage regulator which links the microcontroller and NFC reader to properly supplied with enough required power.

3. LM 1117 3v3 module – Level Shifters which provides security to the Wi-Fi module and Biometric Sensor causing damage by improper power level supply.
4. Arduino MEGA 2560 – The microcontroller and main backbone of the device where the other modules are attached.
5. ESP8266 01 – Wi-Fi module that links to the mobile device of the user and other devices in a LAN.
6. RTC DS 3231 – Serve as the real time clock to make the monitoring updated.

B. Testing Results

i. Testing the NFC Reader

The proponents test different three NFC readers and have come to these results shown below.

NFC Reader	NFC tag/card	Orientation (Parallel to the module)	Mean of Range (cm)
ACR122U	NFC tag (MIFARE Classic 1k, 13.56MHz)	30° horizontal	2.7
		180° vertical	3.4
	NFC Card (NXP MIFARE Ultralight C)	30° horizontal	4.6
		180° vertical	5.3
RC522	NFC tag (MIFARE Classic 1k, 13.56MHz)	30° horizontal	2.4
		180° vertical	3.1
	NFC Card (NXP MIFARE Ultralight C)	30° horizontal	2.3
		180° vertical	3.4
R20C-USB-8H10D	NFC tag (MIFARE Classic 1k, 13.56MHz)	30° horizontal	1.4
		180° vertical	2.1
	NFC Card (NXP MIFARE Ultralight C)	30° horizontal	2.5
		180° vertical	3.3

TABLE I. NFC Reader Summary of Results

The RC522 RFID Reader perform sufficient sensitivity which was good enough to read and recognize NFC card/tag. It gives an excellent performance at database compatibility and easily configured. Unfortunately, ACR122U reader that was more sensitive and better to use in such application, it had difficulty performing because of database issues. On the other hand, R20C-USB-8H10D was the least sensitive of the three and performs poor at database compatibility though it is easy to configure.

Overall, the result of both tests executed to the NFC readers gives an opportunity to the proponents to conclude and resolve what reader was suitable for the project application.

ii. Database Testing

The database stores data coming from the ESP8266 client. Each device that was supposedly deployed to the four rooms of ECE department, which are the COE 23, COE 52, COE 43 and Accreditation room. The proponents tested the ability of devices ability to communicate to the database together with the android application.

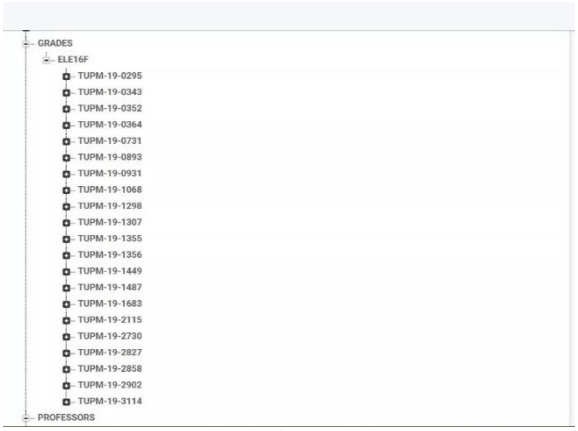

Fig. 10. Recorded Data of Uploaded Grades

Fig. 11. Recorded Data of Registered Students

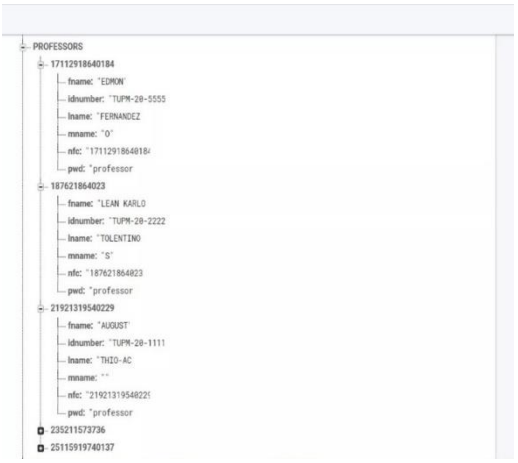

Fig. 12. Recorded Data of Professor

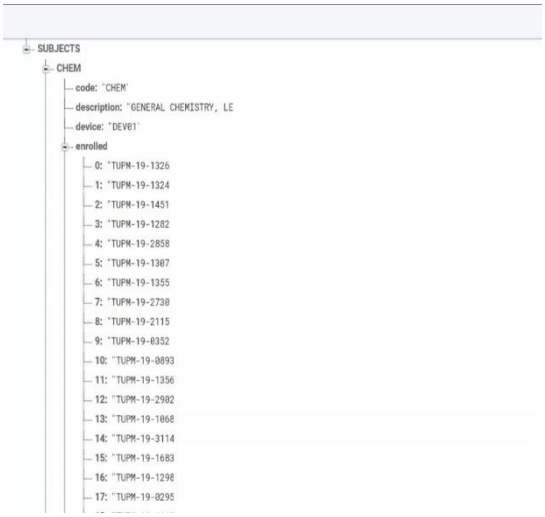

Fig. 13. Sample Data of Subjects with Students Enrolled

Fig. 14. Sample Data of Attendance History

iii. Mobile Application

The proponents tested the response synchronization of built mobile application to the designed door lock in card registration and authentication in addition, the interface transition at user's mobile device and communication with the database was also tested.

Figure 15: Viewfinder of Uploaded Grades in Professor's Interface on Built Mobile Application

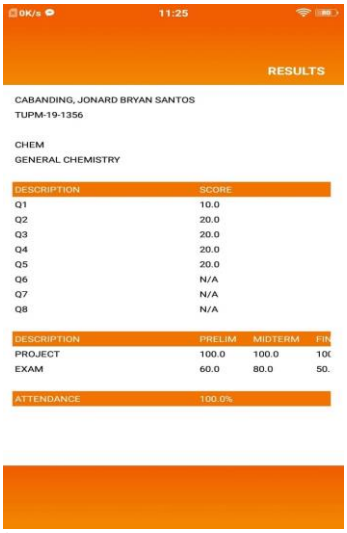

Figure 16. Display of Student own Grades on their Mobile Application

iv. Authentication Accuracy Test

The proponents tested the accuracy of the authentication ability of the nodeMCU. Due to the two-factor input requirements of the device before it completely accessed such as NFC card as initial input and fingerprint scanning as biometric authentication either the two that hasn't satisfied means that the device cannot be accessed. Furthermore, operation process of the device block the user's attempt to proceed to the database if NFC card and Fingerprint are not recognized. Overall, the functionality and authentication ability of the system is 100% working.

In addition, the process of first-time registration of the student from the device and response of mobile device application was also tested. Tabulation summary of the procedure and responses at time are shown below.

Steps for first time register of student	Occurrence in the mobile application and device	Time (sec)
Filling up the form	Requires information such as: First name Last name Middle name ID number	10-15
Setting of NFC card	Before yellow LED light up	2-4
	Yellow LED light up and read a card last	5
	Recognizing the NFC card	2
Setting of fingerprints	Before fingerprint scanner light up	3-5
	Fingerprint recognition	1-2
	Fingerprint recording	5-15

TABLE II. Summary Result of Door lock Device and Mobile Application Response

V. CONCLUSION

After the results are in, looking back on the objectives already set, the researchers conclude that:

The program developed and uploaded in the Arduino Mega 2560 is capable of controlling the door lock and integrating the entire system. This code includes the activation of PN522 NFC module, controls the solenoid lock through a relay driver, reading of the GT-512F32 fingerprint scanner, and the connection of the ESP8266 Wi-fi module.

The RC522 is an RF module composed of an RFID reader, an RFID card and a key chain that works seamlessly with the device and proved that the ESP8266 client could interact with the system. The module operates 13.56MHz which is an industrial band (ISM) and can therefore be used without any license issue. The module usually works at 3.3V and is most widely used in 3.3V designs RC522 RFID Reader performed enough sensitivity to read and recognize NFC card / tag to create a database that records all data through the lock door hardware done by NFC.

The free software Android Studio was used for creating the mobile application UI and used in ensuring the accuracy of the input data. Using the mobile application, the professor can upload and download the student performance and, students can view their individual performance.

JavaScript was used for Firebase SDK database to record all data collected from the door lock hardware and mobile application.

The final handheld device, as checked, could evaluate data in the reliability of the database and easily configure the user activities and identity.

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