Microcontroller-based Room Access Control System with Professor Attendance Monitoring using Fingerprint Biometrics Technology with Backup Keypad Access System

Dexter D. Geralde, Milton M. Manaloto, Dionn Elijah D. Loresca, Jacqueline D. Reynoso, Eden T. Gabion,
Gabriel Rodnei M. Geslani
College of Engineering and Information Technology
Colegio de San Juan de Letran
Intramuros, Manila, Philippines

Abstract— **The conventional way of opening a room was used in the classrooms and laboratory rooms of the Colegio de San Juan de Letran Engineering building, wherein the doors were unlocked using the key for each doorknob in the building. The switching of lights and air-conditioning units were also manual and time consuming.**

The researchers constructed a prototype focused on automating the access of the room and the control of the utilities such as the lights and the air-conditioning units. Biometrics system specifically; finger print, with a backup code was the main access keys for the automation. The attendance log and the access information will be stored in a SD card and it would serve as the database of the system

The design project with a secured biometric access system aims to lessen the time wasted on waiting for the personnel-in-charge in opening the room and the overstaying of the proffers in a certain class. This also monitored the attendance of the professors per class.

Keywords—automation, room access, Biometrics, finger print and code

I. INTRODUCTION

The term 'Automation' is defined as the technique or method of making an apparatus, a process, or a system operate or work automatically[1].This can be done by incorporating technologies and electronic devices to aid the intended automation needs of an equipment, process, or system.

Automation does not simply transfer human functions to machines, but involves a deep reorganization of the work process, during which both the human and the machine functions are redefined.[2].

In Colegio de San Juan de Letran, automation is present at the gates of the institution. An RFID card access system is placed in the entrance of the school to monitor the students entering the Colegio. Also the attendance monitoring for employees as well as the student assistants in the Colegio is automated with the use of finger print biometric system for their time-in time-out log whenever they enter and leave the school premises.

The conventional way of opening a room is used in the classrooms and laboratory rooms of the Colegio de San Juan de Letran Engineering building, wherein the doors are unlocked using the key for each doorknob in the building done by the authorized personnel. These keys are stored and being safeguarded by the security and maintenance personnel of the Colegio. The switching of lights and air-conditioning units are also manual and done by the authorized personnel.

The proponents came up with an idea similar to the room access system present on some company offices wherein the employees enter a code whenever they want to access the office. These also serve as there attendance log and monitors how often they go in or go out the premises of the office. The system also aids in the security of the working environment since only employees of their companies can access the office because the code given to them is unique.

The proponents intended to use biometrics system, because it offers several advantages over other authentication methods and there has been a significant surge in the use of biometrics for user authentication in recent years, [3] specifically the use of the fingerprint as main access key for the room and main switch for the utilities including the lights and air-conditioning units. An attendance monitoring system was also added to the room access automation that summarizes the time the professor accessed the rooms. This feature helps the checker from the human resource department to accurately check the attendance of the professor on each of his or her teaching loads. However, the system used the assigned official schedule to be the basis if the professor can access the room or not. The time scheduling integration with the biometrics system as the access key will add on the security feature of the room access automation.

The 'Microcontroller-based Room Access Control System with Professor Attendance Monitoring using Fingerprint Biometrics Technology with Backup Keypad Access System' used a more secured access key since fingerprint is hard to duplicate and every person possesses unique sets of them.[4] It also automates the switching of the utilities of the room with the use of relay circuits. Alarms were set as indicator of the time duration and limit as programmed

in the microcontroller. An alternative coded access scheme using an LCD with keypad will be added for emergency purposes or when the authorized professor is absent or someone is late. If the professor is absent and there is a substitute for him or her, the code will be from an administrator assigned to open the room on such circumstances and certain conditions. The system utilized will not shut down until the fifteen minute mark lapses, this will be the grace period given for the next scheduled professor to access the room

II. IMPLEMENTATION

A. Design Criteria

The design of the project was based on the following criteria; accuracy, reliability, security, and real time.
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Accuracy Test This would measure how well the system was able to correctly match the biometric information from the same person and avoid falsely matching biometric information from different people.

Reliability
The design project would use biometrics system specifically the fingerprint as the main access key.   The Adafruit Fingerprint Sensor[5] was used for the fingerprint scanning. It is an all in one optical fingerprint sensor with a simple way of adding fingerprint detection and verification.   In these modules, there is a high powered DSP chip that does the image rendering, calculation, feature finding and searching. It could enroll new fingers directly in the on-board FLASH memory.

The system would be backed up with a keypad access feature.   The code would be readily available to the admin office for use with authorized approval. The attendance log or the access information would be stored in an SD card and it would serve as the database of the system.   The information stored in the database should be readily available when needed.

Security
The design project must be secured .A fingerprint scanner system has two basic jobs. It gets the fingerprint image, and it determines the pattern of ridges and valleys in the image to be matched to the pattern of ridges and valleys in pre-scanned images[6].   Only specific characteristics, which are unique to every fingerprint, are filtered and saved as an encrypted biometric key or mathematical representation. No image of a fingerprint is ever saved, only a series of numbers (a binary code), which is used for verification. The algorithm cannot be reconverted to an image, so no one can duplicate the fingerprints
.
With regards to the fingerprint users, only the professor will be enrolled and use the fingerprint room access. The utilities and the admin office will be using the keypad room access provided that it is for an authorized and official room use.   The key codes will be changed and updated regularly to avoid passing on the code to unauthorized individuals and for a more secured system.

Real Time Operation
The design project would be operating in real time. The schedule matching scheme that would work alongside the fingerprints enrolled and the alarm system requires the real time clock.   The proponents will be using RTC DS1307 a compatible RTC module for Arduino boards.
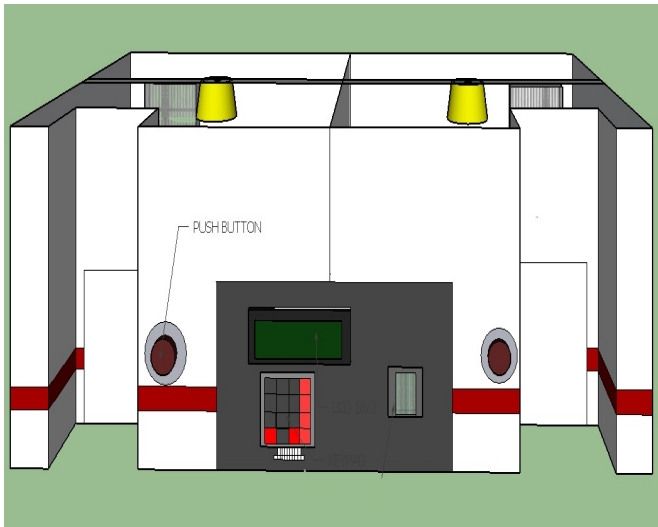
B. Prototype

The prototype was a two mini classrooms integrated
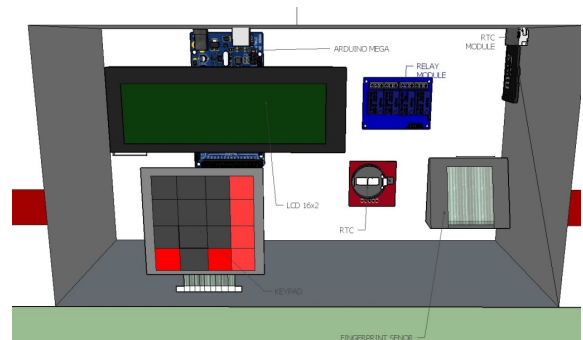
with the control box where the access is made, lock systems one for each door of the room, light indicators for the lights and Ac unit, and the buzzers for the alarm system.   The materials used where light weight and the whole room is placed on top of a mini table for portability and display purposes.

Figure 1. The Control Box with the external and internal components

The Control box is an 8in x 6.25in x 2.8in black plastic box was the main MCU and its peripherals were housed and mounted. In the front of the prototype is where the LCD, keypad and the fingerprint were placed. All other peripherals were housed and compacted inside. The outputs of the system, rooms A and B and also the connection for the supply of the system were wired out from the control box. The SD card slot has its own access area for easy editing of the schedule and access to the logs of the professors.


Fig. 2 Prototype Rooms With the control Box
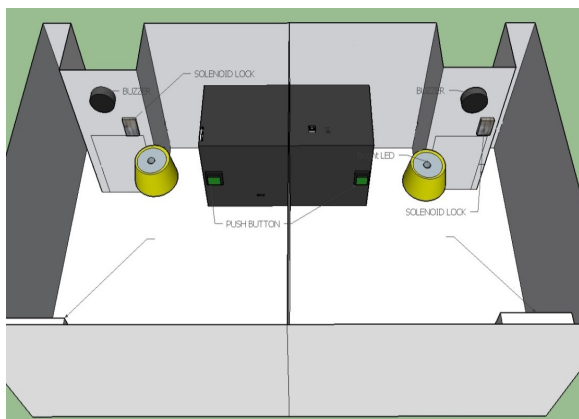
Fig. 3 Interior of the Rooms

The mini-classroom was a 12in x 13.5in x 20.5in, 5mm acrylic casing with two 3.5in x 6in doors. The locks were mounted on the top of the door together with the buzzers. The control box was perfectly fitted to the center of the two rooms wires coming out of the control box are for the output and its power source. The utilities being controlled were represented with LEDs. Two light indicators for each room were placed to represent the on and off of the lights and the air-conditioning unit. The whole prototype was placed on a mini-table

C. Operational Diagram
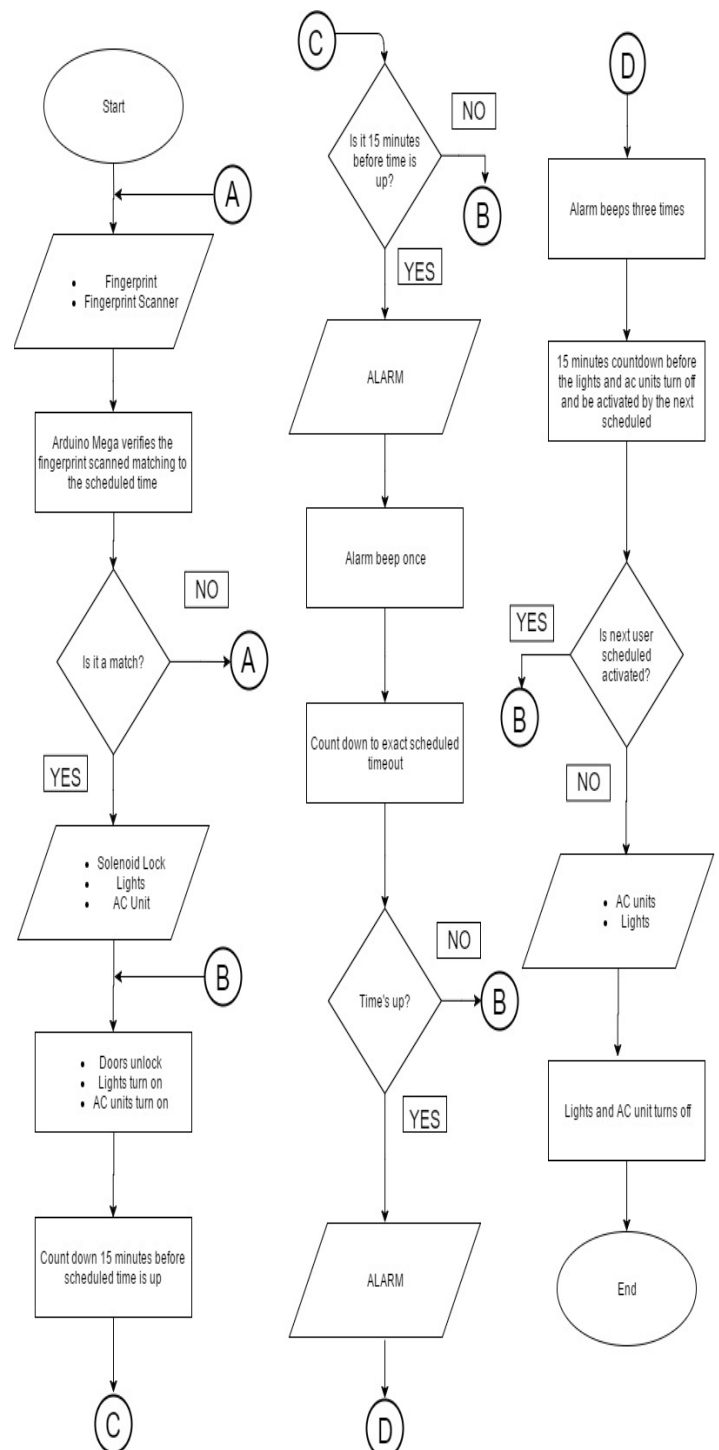
Fig. 4 Operational Flow Diagram

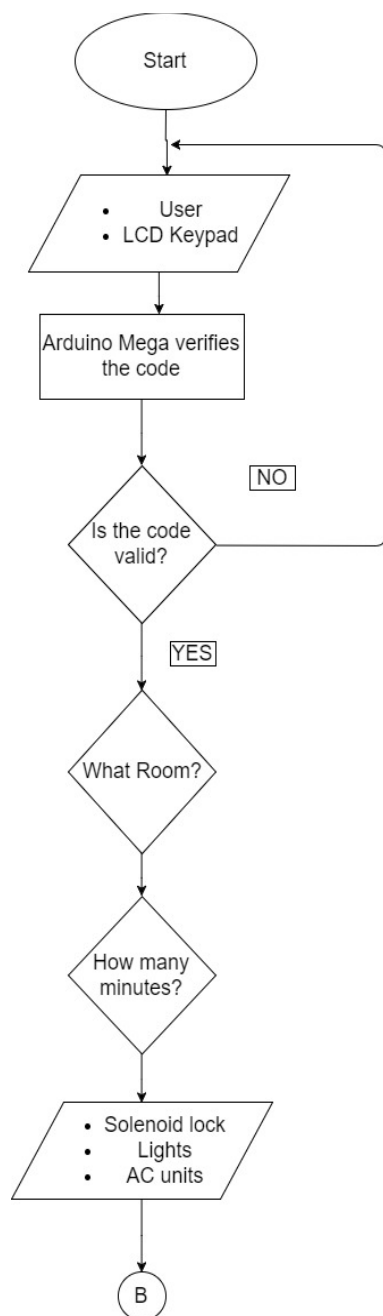**For Emergency Access**   **For Exit (if 15 minutes extension lapses)**   **For Late Students' Access**

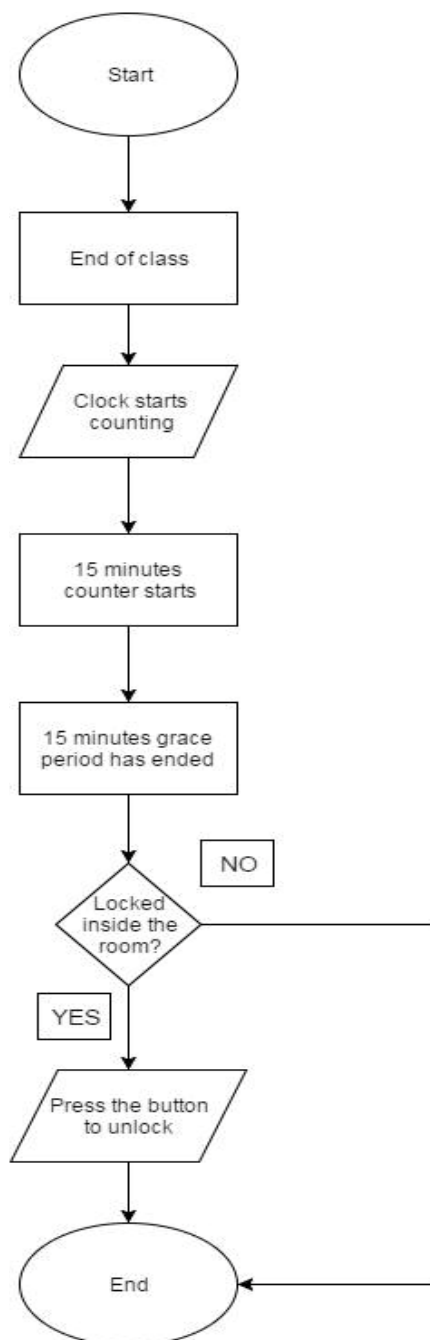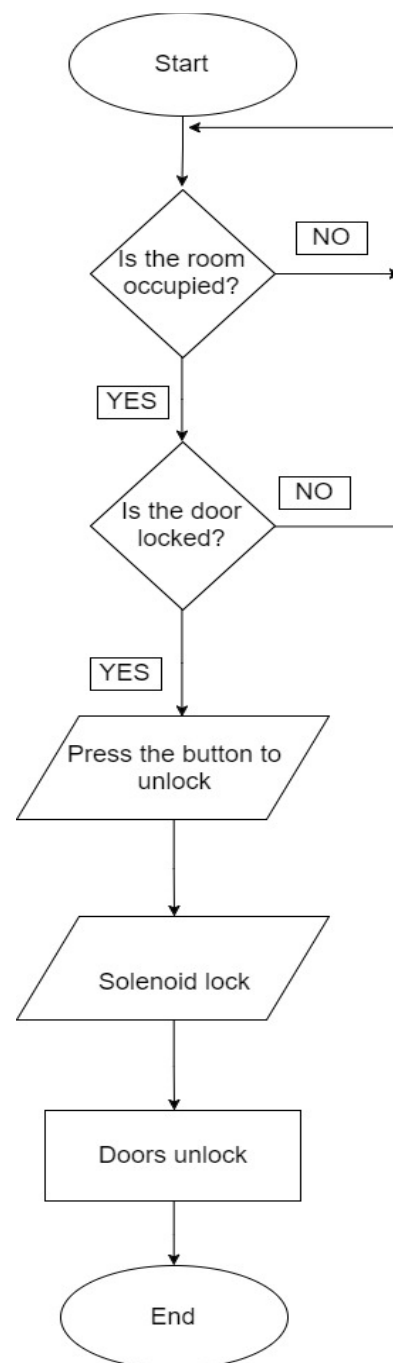**Fig. 5 Emergency access**   **Fig. 6 Exit (if 15 minutes extension lapses)**   **Fig. 7 Entrance when the door is locked**

The figures exhibited the process flow of the system and how it should operate under certain conditions. The main access key for this design was the fingerprint of the user enrolled and the code during emergency access. The fingerprint was the center biometrics element and considered as the primary input of the project as shown in the flow chart. The matching of scanned fingerprint and schedule in the database of the MCU would trigger the whole project to work as explained in Figure 4 The door lock, lights, and AC units were the primary output of the design project. Alarms are set to inform the user that his or her time was about to end or has ended. 15 minutes before the schedule timeout the alarm would beep once and should beep three times when the time scheduled was up.

When the user is not around but the room was needed to be accessed a code should be inputted to the LCD keypad for the room to be accessed as well as the lights and AC unit to be on. If the students of the professor are late they should press the button outside to unlock the door if the room is occupied. If the users of the room stayed for more than the allotted time and the system locks, an emergency button is used to unlock the door for them to leave the room as shown in figure 6 After they vacate the room and the time is up, the door would be locked when shut. For emergency access the keypad access code should be inputted, then the system would ask if which room to open and for how long as shown in Figure 5.

The access and lock code for the maintenance personnel should be changed regularly for a more secure access of the rooms. As shown in figure 7, whenever a student was late he or she pushes the button to unlock the door since the door accessed using a fingerprint or keypad will only be unlock for 5 seconds.

III. RESULTS

Accuracy and Security Test

The test involved ten unique enrolled fingerprints each of which was scanned ten times to determine whether the system will recognize (VALID) it or not (INVALID). All of the fingerprints that were scanned should appear valid in the system. **V- Valid, I -Invalid**

Table 1: Enrolled Fingerprint Validity Test

Enrolled Fingerprint Validity Test									
Fingerprint	**Trial1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	I	V	V	V	V	V	I	I	V	I
2	V	V	V	V	V	V	V	V	V	V
3	V	V	V	V	V	V	V	V	V	V
4	V	V	V	V	V	V	V	I	V	V
5	V	V	V	V	V	V	V	V	V	V
6	V	V	I	V	V	I	I	V	V	V
7	V	V	V	V	V	V	V	V	V	V
8	V	V	I	V	V	I	I	V	I	V
9	V	V	V	I	V	V	V	I	I	V
10	V	V	V	V	I	V	V	V	I	I

For fingerprint 1 and 8, out of 10 trials, 6 were valid and 4 invalid, garnering a 60% accuracy rate. Fingerprints 2,3,5,7 showed all trials were valid. Fingerprint 4 shows 90% accuracy and fingerprints 6, 9 and 10 revealed 70% accuracy. The test results also showed that during every trial, if the fingerprint is valid, the system outputs which include the door lock, room utilities, and the alarm system, functioned properly.

In Table 2, the test used ten unique fingerprints and conducted ten trials for each fingerprint. All of the fingerprints are not enrolled in the system. The system should show no valid fingerprints scanned in the test. **V-Valid, I –Invalid**

Table 2: Validity test of Fingerprints not enrolled

Unenrolled Fingerprint Validity Test									
Fingerprint	**Trial1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	I	I	I	I	I	I	I	I	I	I
2	I	I	I	I	I	I	I	I	I	I
3	I	I	I	I	I	I	I	I	I	I
4	I	I	I	I	I	I	I	I	I	I
5	I	I	I	I	I	I	I	I	I	I
6	I	I	I	I	I	I	I	I	I	I
7	I	I	I	I	I	I	I	I	I	I
8	I	I	I	I	I	I	I	I	I	I
9	I	I	I	I	I	I	I	I	I	I
10	I	I	I	I	I	I	I	I	I	I

The ten fingerprints involved in the test showed invalid state; therefore, this guarantees that the system will not accept fingerprints that are not enrolled in the system. It was observed, also, that the lock system, room utilities and alarm were not activated. It is safe to say that no fingerprint that is not enrolled will ever access the system.

Reliability Test

The test measured the response time when inputs were placed using the keypad and if the whole system works properly on the rooms. The keypad access code is a four digit code (pass code: 1234). The system should allow access, switching of utilities, and sounding off of the alarm when the correct code is placed.

Table 3: Keypad Test in Opening Room A

Keypad Test Opening Room A					
Trial	**Solenoid Lock**	**Light Indicator**	**AC Indicator**	**Alarm1**	**Alarm2**	**Input Time Response**
1	✓	✓	✓	✓	✓	19.05
2	✓	✓	✓	✓	✓	16.41
3	✓	✓	✓	✓	✓	17.32
4	✓	✓	✓	✓	✓	25.15
5	✓	✓	✓	✓	✓	17.11
6	✓	✓	✓	✓	✓	19.38
7	✓	✓	✓	✓	✓	20.61
8	✓	✓	✓	✓	✓	27.62
9	✓	✓	✓	✓	✓	18.02
10	✓	✓	✓	✓	✓	16.01

The table shows that the data indicating the whole system worked properly using the keypad access feature. However, there were differences on the time response. The input time response was recorded in seconds from the ten trials done with an average of 19.668 sec. or approximately 20 sec.

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Real Time : Attendance Log Test and Data Interpretation

The proponents enrolled five (8) unique fingerprints and assigned succeeding schedules for each fingerprint to test the operation of the system for multiple access on a scheduled day and to check if the attendance log produces correct time in log of the fingerprint

Table 4 The Assigned Fingerprints with Their Schedule and Attendance log

TRIAL	User or FP number	Schedule (Day, Time-start, Time-end, Room)	Log(SD) (FPnumber Date Time FP was scanned or code was Day)	Remarks
1	9	9.txt - Notepad Sn,1000,1100,A Th,0900,0945,B	7 2017/3/9 9:02AM Th -1 2017/3/9 9:40AM Th -1 2017/3/9 9:53AM Th -1 2017/3/9 9:55AM Th	The Professor was absent, keypad was used to open the room
2	7	7.txt - Notepad Tu,1700,1800,A Tu,1700,1800,B Tu,1800,1900,B St,0900,1100,A Th,0840,0900,B Th,1005,1010,A	-1 2017/3/9 9:55AM Th 2 2017/3/9 10:03AM Th 7 2017/3/9 10:05AM Th -1 2017/3/9 10:11AM Th -1 2017/3/9 10:12AM Th 8 2017/3/9 10:15AM Th	The Professor was on-time
3	8	8.txt - Notepad Sn,1000,1100,A Th,1015,1020,A	-1 2017/3/9 10:11AM Th -1 2017/3/9 10:12AM Th 8 2017/3/9 10:15AM Th 2 2017/3/9 10:17AM Th	The Professor was on-time
4	1	1.txt - Notepad St,2100,2148,A Sn,1100,1340,A Mn,1900,1930,A St,1800,1830,B Sn,0700,1530,A Fr,1700,1800,A Th,1115,1120,A	2 2017/3/9 11:17AM Th 1 2017/3/9 11:18AM Th 1 2017/3/9 11:20AM Th 3 2017/3/9 11:30AM Th	The Professor was late
5	2	2.txt - Notepad Tu,1700,1800,A Tu,1700,1800,B Tu,1800,1900,B Th,1120,1130,A	1 2017/3/9 11:18AM Th 2 2017/3/9 11:20AM Th 3 2017/3/9 11:30AM Th 4 2017/3/9 11:39AM Th	The Professor was on-time
6	3	3.txt - Notepad Tu,1100,1200,A Tu,1300,1350,B Th,1130,1140,A	1 2017/3/9 11:18AM Th 2 2017/3/9 11:20AM Th 3 2017/3/9 11:30AM Th 4 2017/3/9 11:39AM Th	The Professor was on-time
7	4	4.txt - Notepad Sn,1000,1100,A Th,0900,0945,A Th,1140,1150,A	3 2017/3/9 11:30AM Th 4 2017/3/9 11:39AM Th 5 2017/3/9 11:50AM Th 6 2017/3/9 12:00PM Th	The Professor was early
8	5	5.txt - Notepad Sn,1000,1100,A Th,1150,1200,A	4 2017/3/9 11:39AM Th 5 2017/3/9 11:50AM Th 6 2017/3/9 12:00PM Th -1 2017/3/9 12:04PM Th	The Professor was on-time

This table showed the summary of the access log representing different cases of access attempts during the testing day.

Trial 1: The person scheduled on this time was absent and the keypad was used to access the room.

Trials 2, 3, 5, 6 and, 8: These trials demonstrated the on-time scanning of fingerprints to access the room

.

Trial 4: This trial showed that the scanned fingerprint was late on scheduled time. However, access was allowed since it was within the time schedule.

Trial 7: The fingerprint scanned was 3 minutes early of the class schedule. This attempt was allowed access because the open margin of the access was assigned to 5 minutes before the scheduled time for a valid fingerprint.

The data from the log was matched to the schedule and summarized on a suggested document the HR department could utilize.

IV. CONCLUSION

The fingerprint access system was accurate since the proponents used 10 unique fingerprints enrolled and scheduled to the system with 10 trials for each and garnered a result of 82 valid fingerprints scanned out of 100 fingerprint scanned attempts. Scanning errors were due to the fact that there were different ways the fingerprint was placed on the scanner.

The fingerprint access result for the fingerprints not enrolled showed that the fingerprint access system assured that the room is secured from unauthorized access. This goes to show that the fingerprint system was properly working and was secured. Also in terms of security the push buttons were working for access and exit depending on the conditions.

The access thru keypad input of passcode system worked smoothly with a less than 20 seconds input response time. Less time was consumed than going to the information desk just to let the personnel open the door using the conventional key.

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Dexter D. Geralde is a graduate of B.S. Electronics Engineering and a member of the Pioneer Batch of Engineering Graduates at Colegio de San Juan de Letran-Manila. He was formerly the ECE council president of the Letran Engineering society of his batch and an active Board of Director of the IECEP Manila Student Chapter.

Dionn Elijah D. Loresca is a graduating student of B.S. Electronics Engineering at Colegio de San Juan de Letran-Manila and an active member of the Letran Engineering Society and IECEP Manila Student Chapter.

Milton M. Manaloto is a graduate of B.S. Electronics Engineering and a member of the Pioneer Batch of Engineering Graduates at Colegio de San Juan de Letran-Manila. He is an active member of the Letran Engineering Society and Youth for Christ - Letran, and a Board of Director in IECEP Manila Student Chapter.

Gabriel Rodnei Geslani is a Registered Electronics Engineer, IECEP-Member and a full time college instructor at the Colegio de San Juan de Letran (has previously taught at University of Santo Tomas). He is a graduate at the University of Santo Tomas having obtained a Bachelor's Degree in Electronics and Communications Engineering last 2010. He is currently finishing his Master's Degree in Electronics Engineering at the Mapua Institute of Technology. His research interests are Robotics and Automation Systems, Instrumentation and Control Engineering, and Embedded Systems.

Eden T. Gabion is a Registered Electronics Engineer, IECEP-Member and a full time college instructor at the Colegio de San Juan de Letran (has previously taught at AMA Computer College - Makati). She is a graduate at the Mapua Institute of Technology having obtained a Bachelor's Degree in Electronics and Communications Engineering. She is currently finishing her Master's Degree in Engineering Education at Rizal Technological University. Her research interests are Wireless Communication Systems and Technology/Education Management Solutions.

Jacqueline D. Reynoso is a Registered Electronics Engineer, IECEP-Member and a full time college instructor at the Colegio de San Juan de Letran (has previously taught at AMA Computer College - Makati). She is a graduate at the University of the East - Manila having obtained a Bachelor's Degree in Electronics and Communications Engineering. She finished her Master's Degree in Engineering Education and Doctor of Philosophy on Technology Education Management at Rizal Technological University. Her research interests are Embedded Systems and Technology/Education Management Solutions