PROCEEDINGS OF ELECTRICAL ENGINEERING CAPSTONE SHOWCASE (EECS2020)

Smart School

Electronic and Computer Engineering Division
School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia
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ELECTRICAL ENGINEERING CAPSTONE SHOWCASE

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SMART SCHOOL

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PREFACE

The capstone design project in the School of Electrical Engineering is a compulsory course for final year undergraduate students. This course is offered to produce community-cognizant individuals who are able to address community or industry based problems using appropriate techniques, skills, and modern engineering tools. In addition, elements such as project management and teamwork in diverse teams are included and assessed throughout the study.

This publication consists of all the work presented during the Electrical Engineering Capstone Showcase (EECS 2020), which was held on 25th January 2021 organized by the School of Electrical Engineering, Universiti Teknologi Malaysia. The EECS 2020 was the platform for more than 300 students to share and exhibit their ideas and projects which they have worked on for that semester. Panels who evaluated their work consist of academicians and industrial representatives who faithfully had provided valuable insights to further improve the students' work.

The projects reported in the Proceedings of Electrical Engineering Capstone Showcase 2021: Smart School could serve as motivation and valuable information for future collaborative projects and for the betterment of the society.

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Classroom Movement Control Identifier

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Abstract: Along with the development of technology, several applications have become smarter with the use of the Internet of Things (IoT). In this capstone project, a prototype is designed for use in a smart school system, particularly for recording attendance and identifying the number of students in class. ESP32 is used as the main microcontroller along with an Infrared sensor and RFID kit. The number of students in class and the list of students present can be retrieved in mobile applications. The mobile application and the prototype are linked using Wi-Fi. This allows the monitoring of the number of students inside the classroom can be viewed from anywhere if an internet connection exists. The prototype demonstrated in this project can be helpful for ease of student attendance and prevent students from missing from class.

Keywords: Smart School; student attendance; counter; microcontroller

Introduction

Smart schools are developed with the use of technology that can facilitate monitoring and maintenance. This is due to the availability of IoT technology that allows monitoring to be done more quickly and easily. For example, electrical appliances such as lights and fans can be turned off from the office without having to be present in class. Schools that have a smart system can facilitate matters, including in the matter of recording student attendance. Apart from that, there is also a need for teachers to monitor the number of students in the classroom to avoid the problem of students skipping classes. This is also necessary to avoid any interruptions occurring during the lesson. With a system that can directly record the attendance of students when the brand enters the classroom, the use of paper can be reduced.

The purpose of this capstone project is to develop a prototype that can be used in school for ease of recording student attendance and monitoring the number of students in class. A survey has been distributed to school teachers at the beginning to find out the issue related to the current implementation in the school. The design thinking process, including ideation, is done to identify possible solutions. From the survey, most of the teachers faced the problem with student attendance taking. In addition, they also have issues related to student movement during teaching and identifying the number of missing students. Due to this, several solutions have been proposed. The main part of this project is the counter and an RFID scanner. The function of the counter is to count the number of students in and out of the class. The function of the RFID scanner is to record the attendance of the students in the class. Students need to scan their cards after entering the class. The data from these systems will be sent to the mobile application in real-time.

Conceive-Design-Implement-Operate Approach

Conceiving

Before starting the design of the prototype, data on how teachers record their student attendance at school was obtained by giving questionnaires to the teachers. There are eleven questions that teachers must answer. The question was created from discussion with all members and the facilitator through the Google Jam board. Figure 1 shows the questions planned for the questionnaire. The question is a mixture of yes-no and multiple-choice questions. The survey questions were distributed using Google Forms.

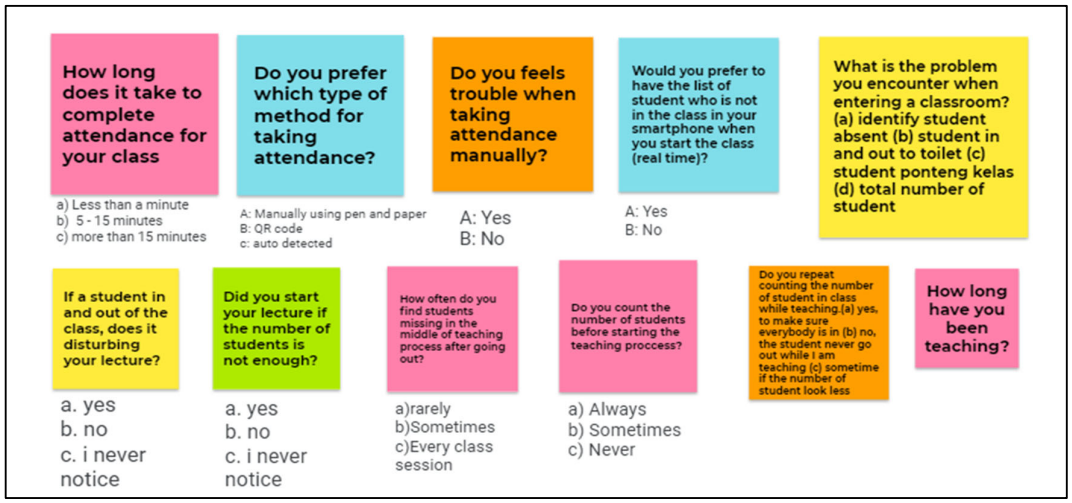

Figure 1: The types of questions in the questionnaire.

Based on the data obtained from the questionnaire, the data were clustered into four parts. The first part is, there are two targeted users, who are teachers and lecturers. The second part is the actual problem and disadvantage of the current practice. From the results of the questionnaire, their first problems are when students are in and out of the class, it will disturb the lecture, and 68.6% of respondents agree with this, as shown in Figure 2. This is followed by a long time taken to record the attendance as 68.6% of respondents state that the attendance process takes around 5-15 minutes, as in Figure 3. From Figure 4, 48.5% of respondents occasionally find students missing during lectures. Meanwhile, 37.4% of respondents find that not enough students during lectures (Figure 5). The third part is on the kind of system that the respondents need. The results show that 48.6% of respondents prefer auto-detected for taking attendance (Figure 6), and 80% of respondents prefer to have the list of students who is not in the class on their smartphone in real-time (Figure 7). In short, the suggestions for the system are an integrated system, an auto-detected method for taking attendance, a standalone system, and an application in smartphones. It also can be shown that the users have high adaptability to the technology.

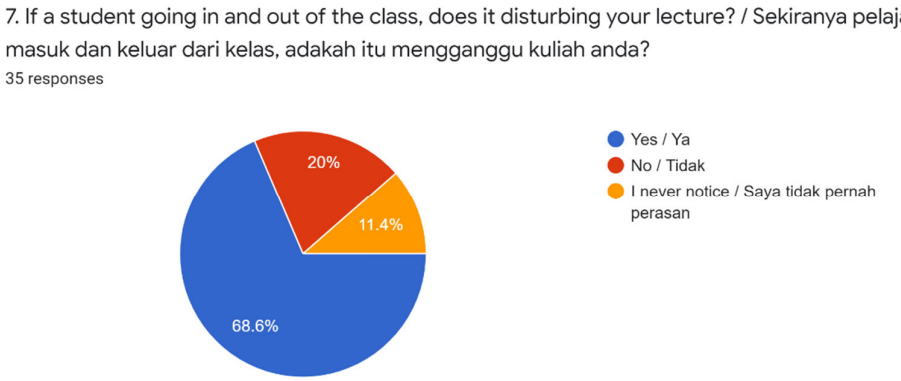

Figure 2: 68.6% of respondents feel being disturbed when students going in and out of the class during the lecture.

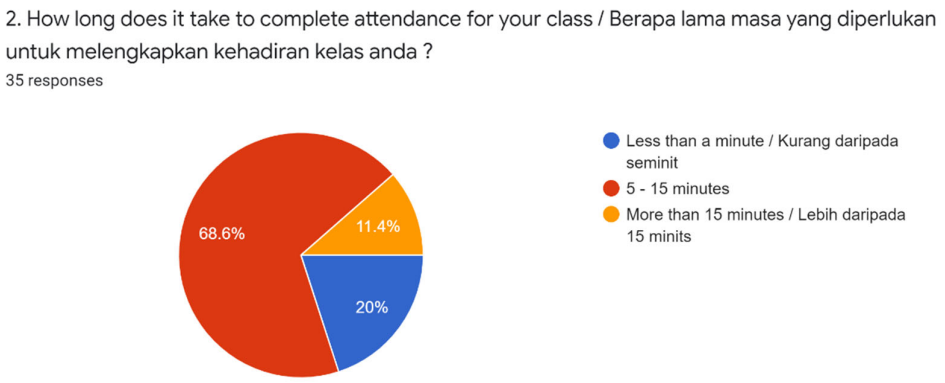

Figure 3: 68.6% of respondents state that the attendance process takes a long time (5 - 15 minutes).

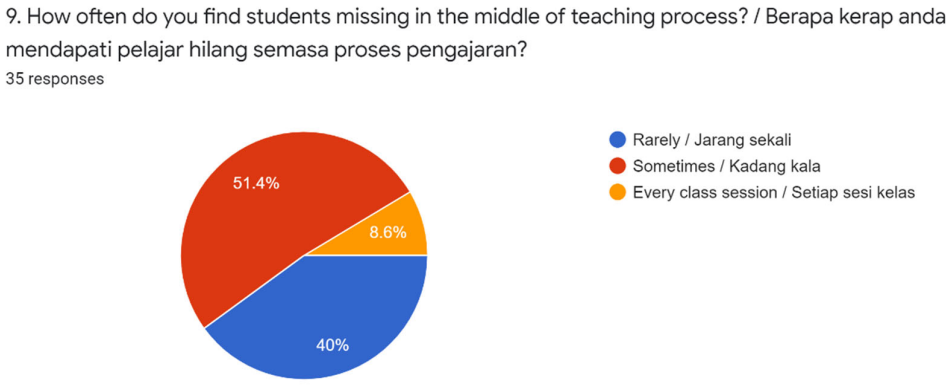

Figure 4: 51.4% of respondents occasionally find students missing during the lecture.

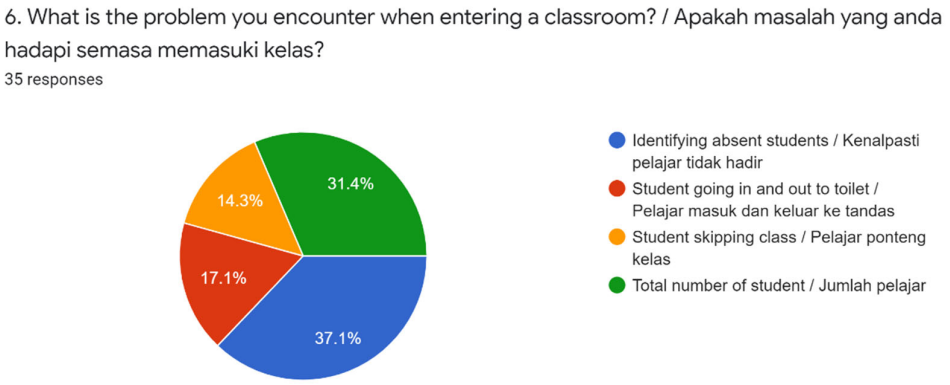

Figure 5: 37.4% of respondents face the problem of not enough students in lecture.

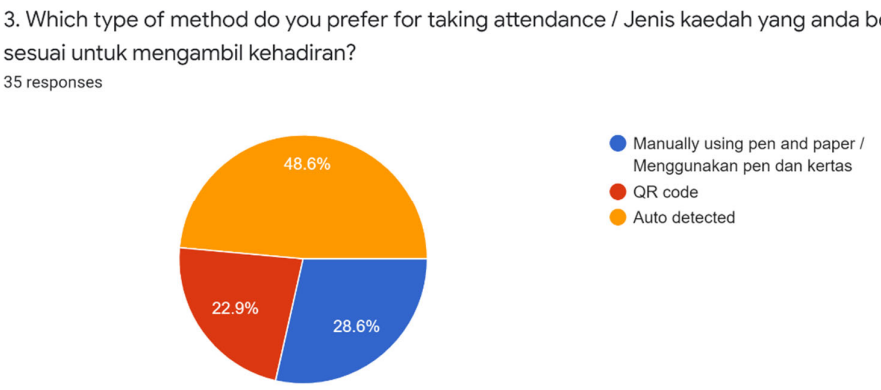

Figure 6: 48.6% of respondents prefer auto-detected for taking the attendance.

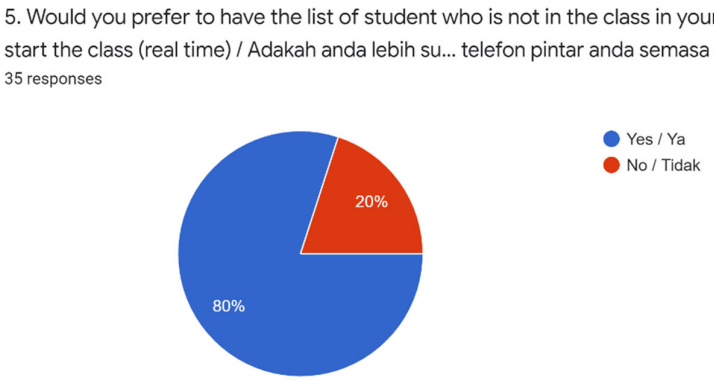

Figure 7: 80% of respondents prefer to have the list of students who is not in the class on their smartphone in real-time.

From the survey response, the data was clustered. An example of this is displayed in Figure 8. From the data clustering, the personification is defined by identifying the user profile, pain – point, user need and the design statement.

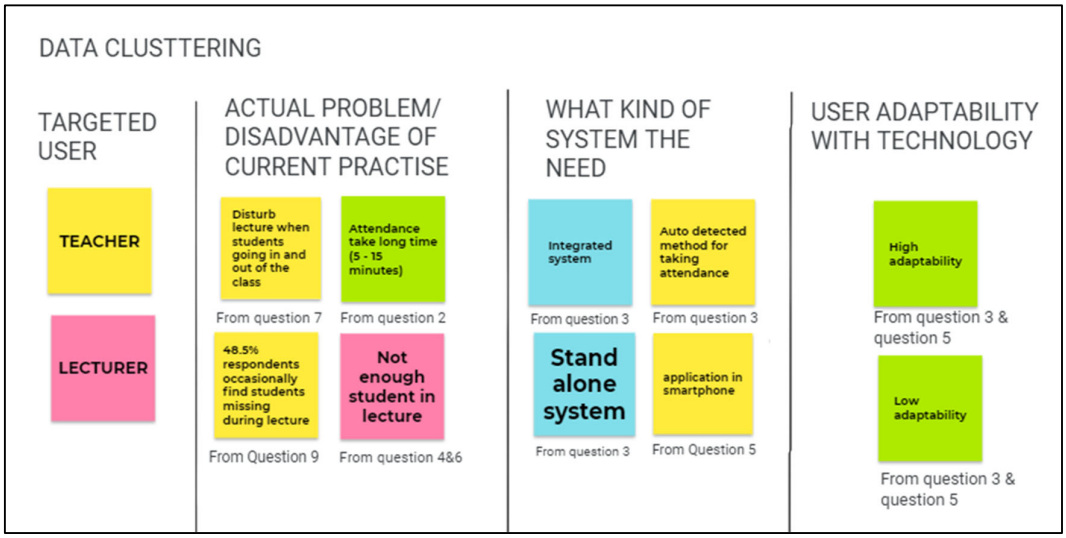

Figure 8: Data clustering for this project

The user profile for this project is an experienced teacher in school and lecturer in the university; a majority have three years of teaching experience, concerned about the number of students in class and preferable auto-detected method for identifying the number of students in the class. There are some user's pain points such as teachers taking time to take attendance, especially the number of students is not enough and need to manually count the number of students at the start of lecture and also in the middle of the lecture. Most of the respondents want a system that can help them count the number of students in the class automatically and a system that can monitor the student in and out of the class automatically. After figuring out the user's need and problem, the design statement for this project is how to ease the teacher to record the number of students in class and identify the absent students. A summary of the personification is shown in Figure 9.

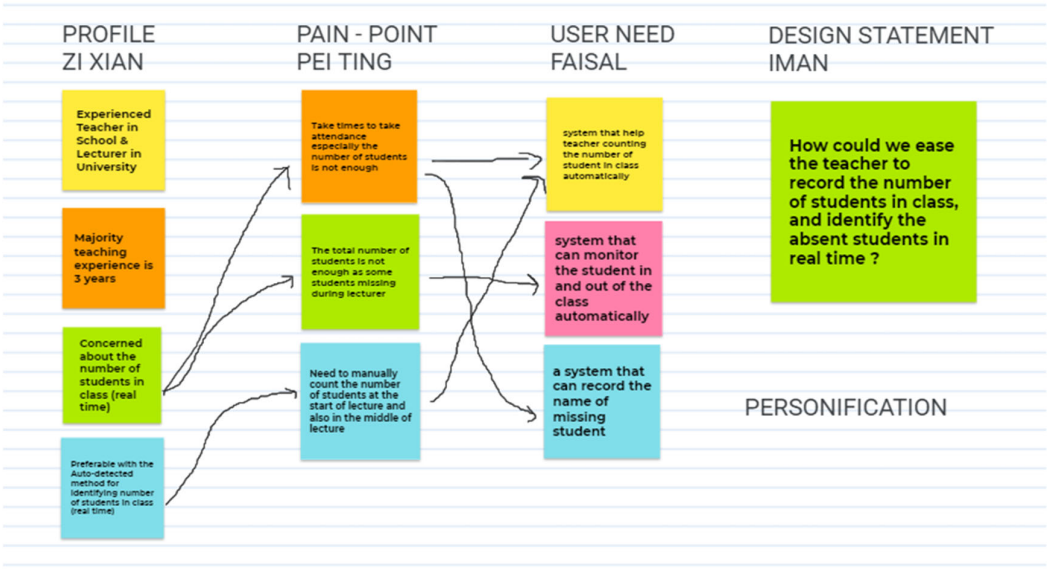

Figure 9: The personification for this capstone project.

Designing

The concept sketch is displayed in Figure 10. The proposed conceptual prototype consists of two parts which are the counter and RFID scanner. The counter is used to detect the student entering and leaving the classroom and records the total number of students in the classroom. The total number of students will be displayed on a seven-segment 2-digit display in the classroom, and it also can be retrieved using the mobile application. The RFID scanner is used to record the attendance of students and the time they enter the classroom. The lecturer can get the attendance list of students by using their smartphones through the mobile application designed by MIT App Inventor.

Figure 12 shows the block diagram of the prototype. It consists of three parts which include the counter, RFID scanner, and mobile application. The first part, which is the counter, consists of two IR sensors, a seven-segment 2-digit display, and an ESP32 nodeMCU microcontroller, while the second part is the RFID scanner which consists of an RFID reader, access card, and ESP32 nodeMCU microcontroller. The third part is the mobile application which is used to retrieve the total number of students in the classroom and the attendance list of the students. The STEEP analysis is summarized in Table 1.

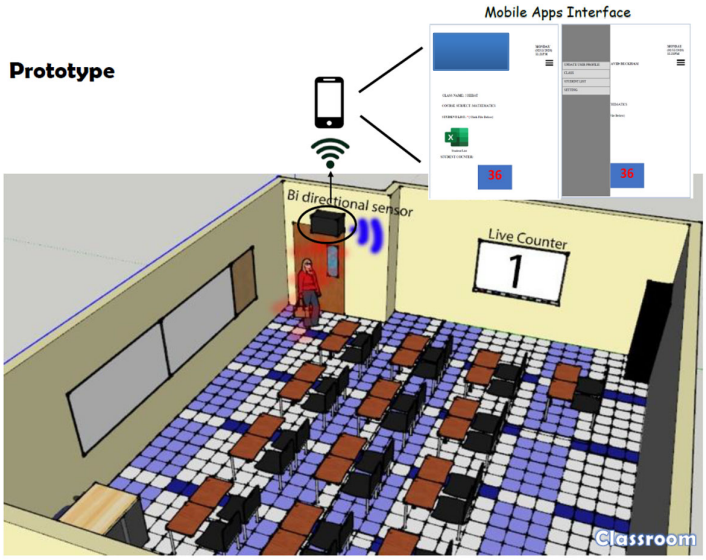

Figure 10: The concept sketch of the classroom movement control identifier system

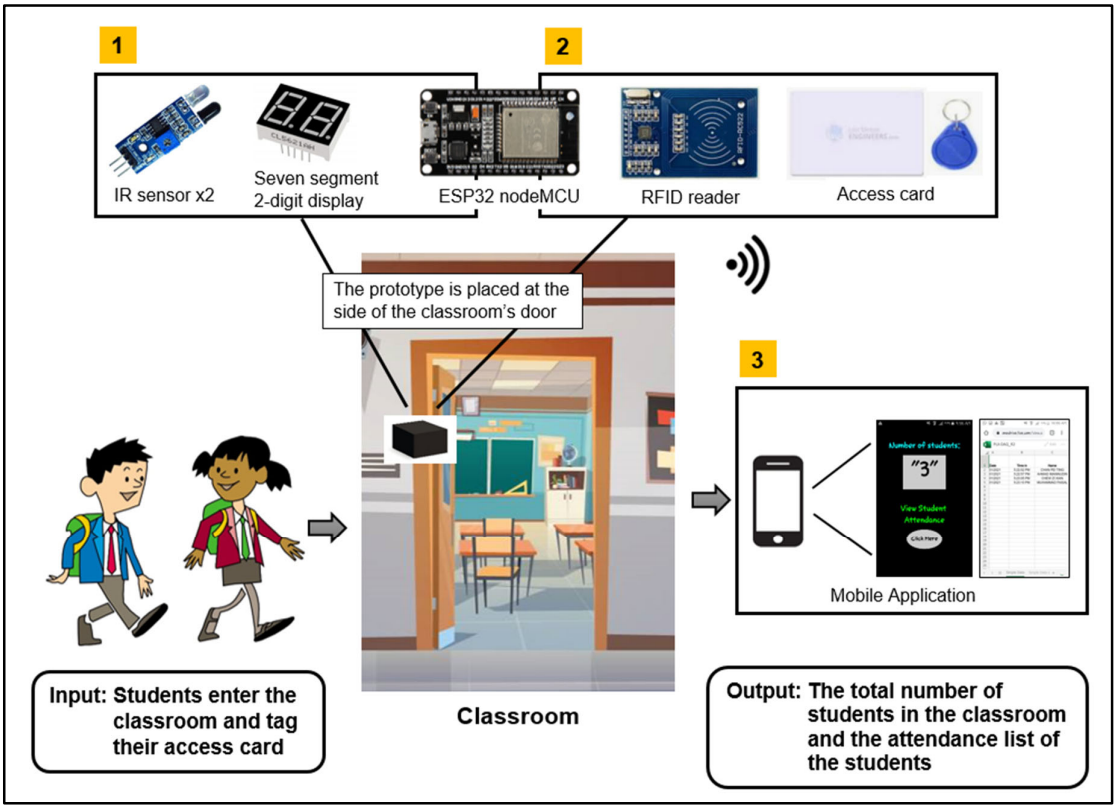

Figure 11: The block diagram of the prototype

Table 1: The STEEP analysis of the developed prototype.

Aspect	Discussion
Sociological	Solve issues regarding student's attendance taking process and students skip class
Technological	Use existing sensor to create a smart attendance tracking system
Economic	The cost of the system is affordable by students
Environmental	The system can be reused in all the classroom
Political	Improve teaching process

The flowchart for the counter is shown in Figure 12. Arduino code is written using Arduino IDE, and it will initialize the connection to the Blynk server. After that, if the first IR sensor, which is located at the front door, detects a student,

it will increment the total number of students. On the contrary, if the second IR sensor, which is located at the back door, detects a student out, it will decrement the total number of students. Lastly, it will upload the total number of students to the Blynk server and then display it on a seven-segment 2-digit display and mobile application.

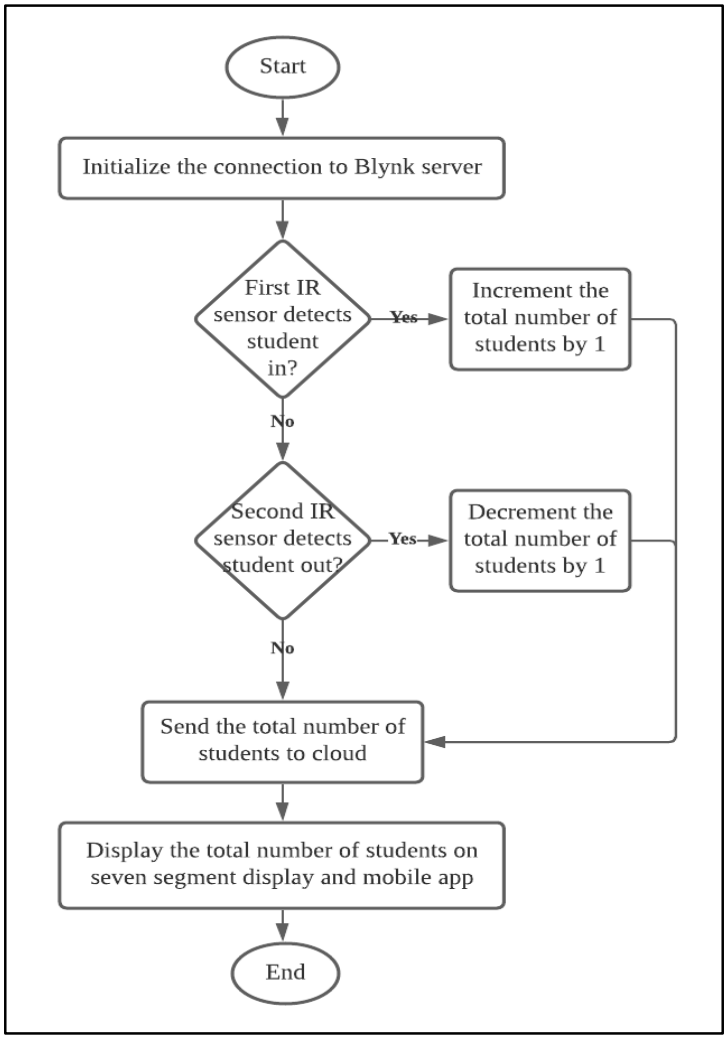

Figure 12: Flowchart of the counter.

Figure 13 shows the RFID system flowchart. The code is written using Arduino IDE. The system initializes when students tag their RFID cards to the scanner. After detecting the card, the system will check whether the identification matches with the students of the class. If it matches, students' information would be stored in the cloud. If it does not match, the system will ignore the card, and no information will be written in the cloud. This process will be looped until all the students in the class scanned their RFID cards. Information stored in the cloud will be retrieved by the mobile application created.

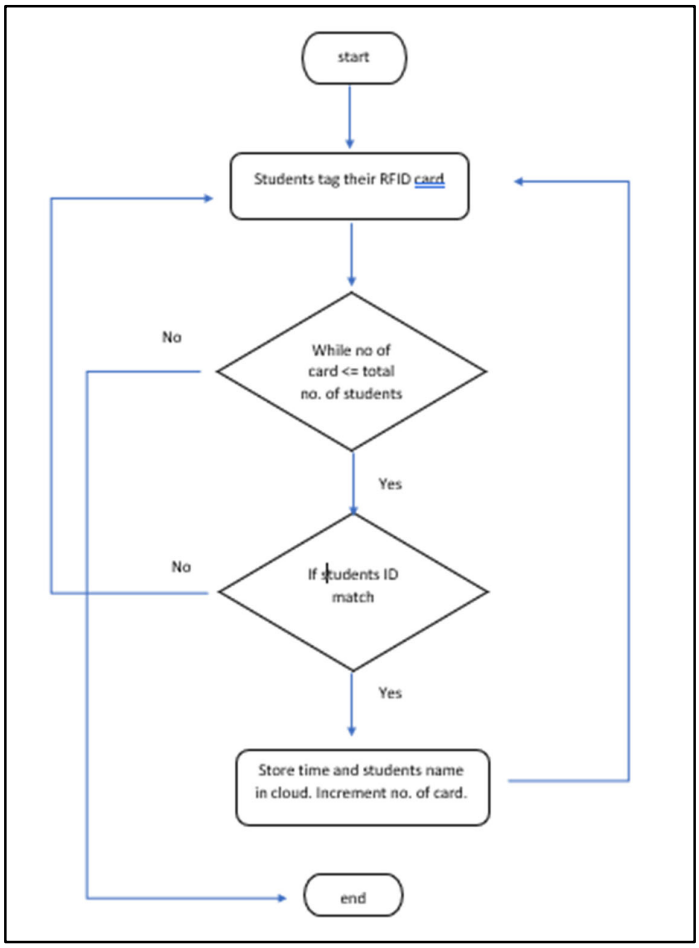

Figure 13: Flowchart of the RFID scanner.

Moreover, the BOM of the project and the Gantt chart are shown in Table 2 and Table 3, respectively. The total cost of the project is RM104.79 and the project is completed following the Gantt chart.

Table 2: BOM of the project

No	Component	Estimated Cost			Actual Cost	
		Unit Price (RM)	Qty.	Subtotal (RM)	Purchased Price (RM)	Delivery Week and Remark
1	ESP32 Node MCU	33.90	2	67.8	66.54	Week 2
2	Jumper Wire (Male to Female)	3.50	1	3.50	3.50	Week 2
3	Mini Breadboard	2.50	2	5.00	5.00	Week 2
4	Resistor (200 Ohm)	0.05	50	1.00	1.00	Week 2
5	RFID RC522 Card Reader	4.30	2	8.60	13.03	Week 5
6	Seven Segment 2-digit Display	6.50	1	6.50	6.46	Week 6
7	IR Infrared Sensor	2.30	2	4.60	9.26	Week 7
			Total	97	104.79	

Table 3: Gantt chart of the project

No	Tasks	Start Week	End Week	Capstone Week										Remark upon Task Completion
				5	6	7	8	9	10	11	12	13	14	
1	Design project title	5	5	☑										
2	Create10 interview questions	5	5	☑										
3	List of real users/respondents for interview purpose	5	5	☑										
4	A users' profile by using the data clustering method	5	5	☑										
5	Design statement based on the developed users' profile	5	5	☑										
6	Conceptual sketch of the proposed design using IDEO brain	5	5	☑										
7	A conceptual prototype	5	5	☑										
8	Blynk Software and MIT app inventor tutorial	5	5	☑										
9	Circuit Building	6	6		☑									
10	Presentation slides preparation	6	6		☑									
11	Create Google Sheet database	7	7			☑								
12	Create mobile application	7	9			☑	☑	☑						
13	Link MIT apps with google sheet	7	7			☑								
14	Build circuit of the bidirectional counter using IR sensor	8	9				☑	☑						
15	Link the bidirectional counter with the mobile application	8	9				☑	☑						
16	Modify the proposed design with RFID scanner	8	11				☑	☑	☑	☑				
17	Create a 3D casing	8	9				☑	☑						
18	Video Planning	10	10						☑					
19	Demo video preparation	10	12						☑	☑	☑			
20	Final presentation slides preparation	10	12						☑	☑	☑			

Implementing

Firstly, for the counter, the circuit diagram of the counter is shown in Figure 14 and the configuration of the pins of the counter is shown in Table 4. It consists of an ESP32 nodeMCU, two IR sensors, and a seven-segment 2-digit display. IR sensor is an infrared sensor that measures and detects infrared radiation in its surrounding environment. Thus, it can be used to detect the motion of students when they enter and leave the classroom. When a student enters or leaves the classroom, the IR sensor will detect, and it will increment or decrement the seven-segment 2-digit display.

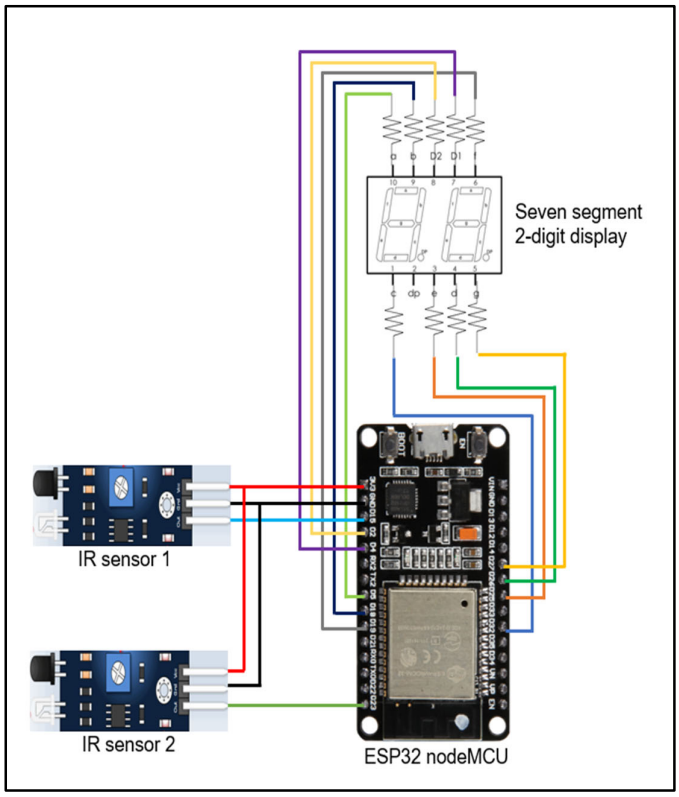

Figure 14: The circuit diagram for the counter

Table 4: The pins configuration of the counter

ESP32 nodeMCU	**Seven Segment 2-digit display**
D5	a
D18	b
D32	c
D26	d
D25	e
D19	f
D27	g
D4	D1
D2	D2
ESP32 nodeMCU	**IR Sensor 1**
D15	Out
ESP32 nodeMCU	**IR Sensor 2**
D23	Out

After connecting the circuit, the Arduino code is uploaded into the nodeMCU to detect the number of students in and out of the classroom and also display the total number of students on the seven segments 2-digit display. The coding consists of initialization, two sub-functions (setup and dis), and the main loop. Firstly, the initialization of the variable 'in' (first IR sensor), 'out' (second IR sensor), 'digit1' (seven-segment display), 'digit2' (seven-segment display), count (total number of students in the classroom and set to 0 at the beginning), 'auth' (authentication of nodeMCU), 'ssid' (wifi ID), 'pass' (wifi password), and Blynk timer are done at the beginning. The 'segPins' array variable is used to declare the pins used for each character of the seven-segment display while the 'segCode' 2D array is used to determine the respective pins for displaying the number.

Next, the pins on nodeMCU are set up as output for the seven-segment display and as input for the IR sensors. At the 'setup' subfunction, the nodeMCU is started with the 'Serial.begin' which tells the serial object to perform initialization steps to send and receive data on the Rx and Tx. Then, establish a network connection, set up Blynk connection details, and try to connect to the Blynk server by using 'Blynk.begin'. For the 'dis' subfunction, it is used for the loop to display the respective digit of the input number.

In the main loop, the code reads the digital value of the two IR sensors as 'in_value' for the first IR sensor located at the front door and 'out_value' for the second IR sensor located at the back door of the classroom. If the IR sensors detect the movement of students, it will give 0 value as it is active low. Thus, when the first IR sensor (in_value) equals LOW, it will increment the count variable and display it on the seven-segment display. Meanwhile, if the second IR sensor (out_value) equals LOW, decrement the count variable and display it on the seven-segment display. At the same time, 'Blynk.run' is used to connect again with the Blynk server and 'Blynk.virtualWrite' will write the value of count to the Blynk server. Thus, the count variable which represents the total number of students can be retrieved by the mobile application as it is ready in the Blynk server.

For the mobile application, the block section in MIT App Inventor consists of three parts and the initialization of variables. Firstly, it initializes the variable of students, header, token, and get V2. The first part is the clock which sets the cloud address and then links to the Blynk cloud server. The second part is to retrieve the content (total number of students) from the cloud server to the mobile application. Finally, the last part is used to direct the lecturers to the attendance list when they click on the 'Click Here' button.

Figure 15 shows the main page of the application and the following screen when the users click on their desired section of the lecture. When the user (the lecturer in this case) opens the mobile application, it will see the class sections available to be chosen such as section 3A, section 3B, section 3C, and section 3D. After the lecturer clicks on their desirable section, the following screen will appear which will show the real-time total number of students in the classroom for the desirable sections. There will be a button named 'Click Here' at the bottom of the screen and the lecturer will be able to see the attendance list of students who are in the classroom in real-time after clicking the button.

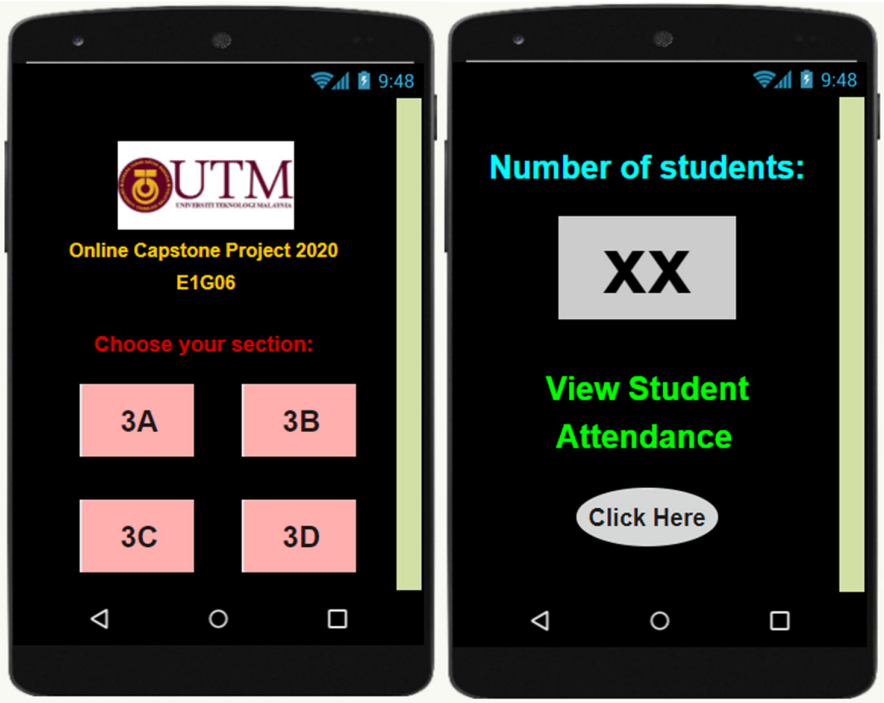

Figure 15: The screen of the mobile application

Lastly, for the RFID scanner, the circuit connection is shown in Figure 16, while pin configuration is as in Table 5. Initially, code is written in Arduino IDE, then uploaded to NodeMCU. After uploading the code, the first test is done by scanning the RFID card and checking whether the output appears in the serial monitor of Arduino IDE. After that, by using PLX-DAQ software, the data from Arduino IDE are written in Excel Spreadsheet. After data is written in the Excel Spreadsheet, it is uploaded to the cloud and ready to be retrieved from the mobile application. The coding for this part had been attached in the appendix. The basic concept of the code is to first assign a name and identification number to a unique address. Then after assigning the information, the system would wait for the RFID card to be detected. If the card address matches with the assigned one in the coding, data will be written in the Excel Spreadsheet. Each card can only be read once to avoid duplication of information.

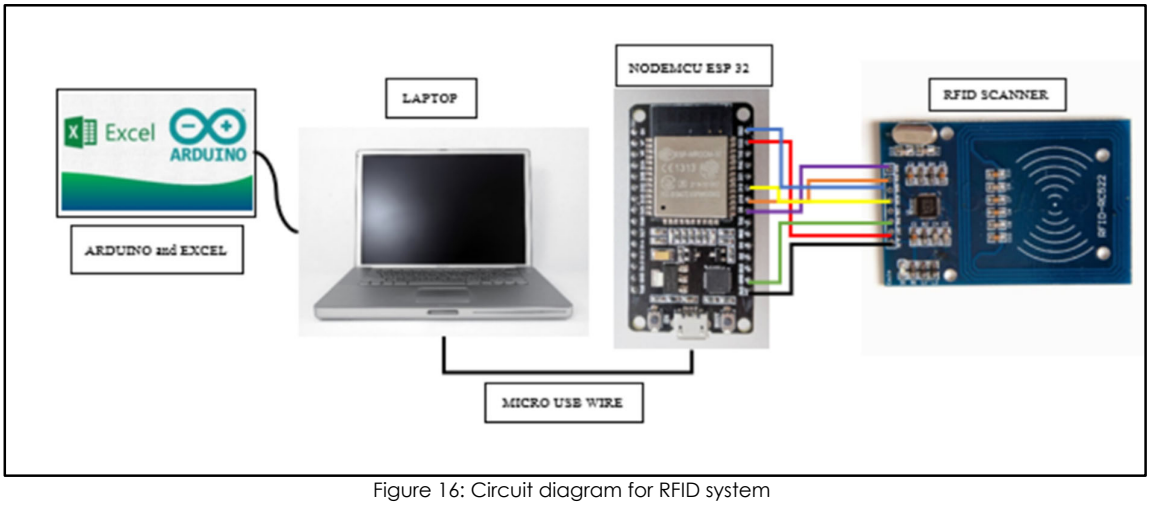

Figure 16: Circuit diagram for RFID system

Table 5: The pins configuration of the RFID scanner

ESP32 nodeMCU	RFID Scanner
3.3V	VCC
D5	SDA
D18	SCK
D23	MOSI
D19	MISO
GND	GND

Operating

Based on the conceptual sketch and prototype, the functional prototype is designed. The flowchart in Figure 17 simplified on the working flow of the system.

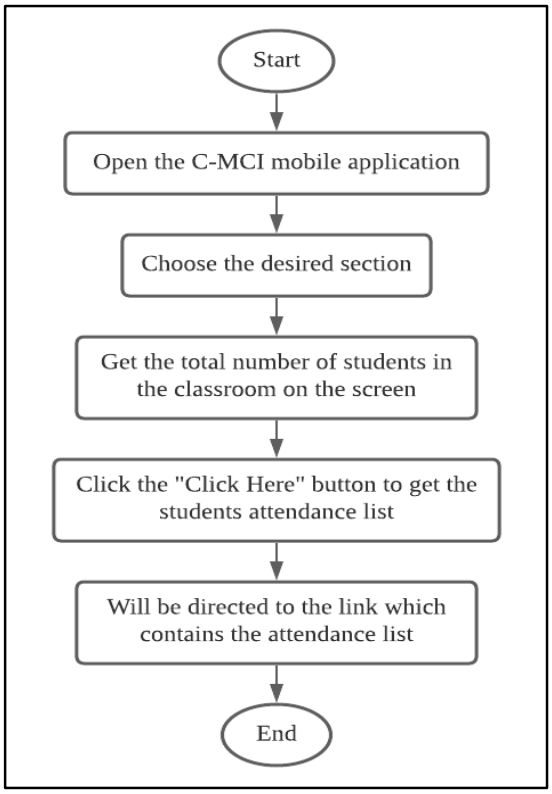

Figure 17: The flowchart of the operation for the prototype

The final functional prototype is shown in Figure 18 and Figure 19. The casing is made from box to fit the 7 – segment display and the IR sensor.

Figure 18: The conceptual prototype of the counter.

Figure 19: The conceptual prototype of an RFID scanner.

The mobile apps are designed with 2 screens as shown in Figure 20. First, the user needs to open the mobile application and the main screen will be shown to let the user choose the section. After that, the user can choose their desired section and they will be able to see the real-time total number of students. By clicking the "Click Here" button, they will be directed to the link which contains the attendance list. The sample is as in Figure 21.

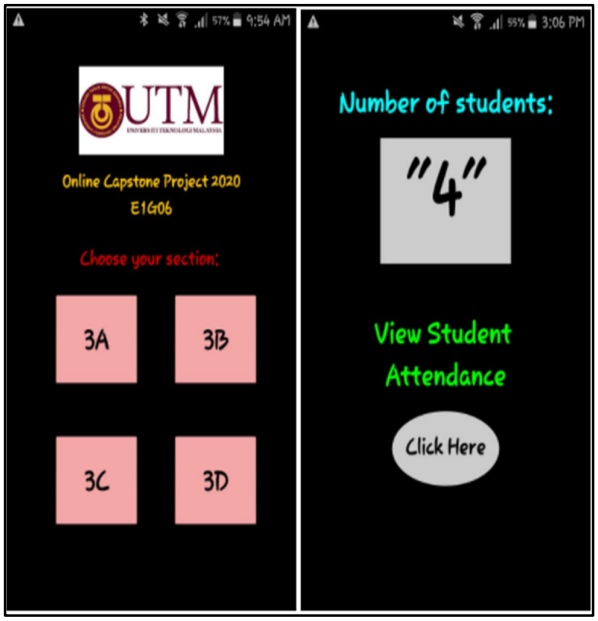

Figure 20: The screens of the mobile application showing the menu

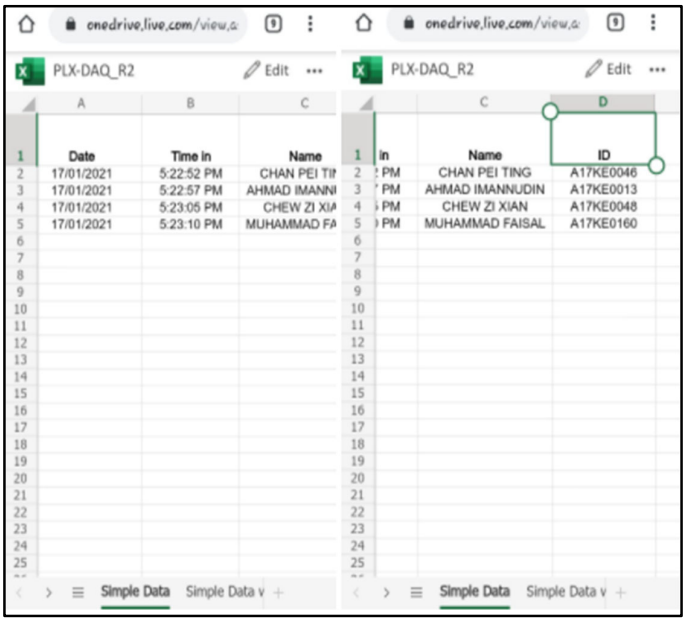

Figure 21: The sample of excel file generates name list

Result and Analysis

The developed product is a great and effective solution for time and attendance management. Teachers can view the number of students inside the class prior to coming to class. While in class, the number of students will be displayed. This is for the teacher to alert if there is any student left the class. In addition, each student will be given an access card with a unique ID. Students entering the classroom need to tap the card on the RFID reader. This system can also be used to record students entering the laboratory or workshop.

Besides, the benefits of the developed prototype are able to reduce the burden of teachers' workload as monitoring and taking students' attendance automatically not only saves a lot of time but also helps teachers focus on the teaching process. This product would be significant when there are numerous students, such as 50 students, in the class. Next, the function of the counter is to record the total number of students and act as a reviewer, which checks whether the total number recorded corresponds with the list of students in the Excel File. This is to detect if there are students who do not scan their RFID cards when entering the class.

Innovation

Our developed product has cost advantages compared to competitor A. However, the product of competitor A is usually a great tool for event organizers and big companies to facilitate large scale events and check employee's attendance as it is convenient for check-ins or attendance tracking through QR codes for participants. Next, the product of competitor A consists of an extra function which is a built-in GPS, where it records the attendance of your employee and with the location of your employee. This is also to avoid the employees to false their attendance as their location can be tracked. Hence, the developed prototype could be improved by a tracking system in order to compete in the marketplace.

Table 7: Comparison with similar products

Features	Competitor A	Developed prototype
Identify the total number of people	QR GPS For Attendance Tracking	RFID Reader
Price	Rm499	RM 2

Conclusion

The prototype of the classroom movement control identifier system presented here can also be used in other sectors for monitoring and displaying the number of people. The system used IoT to link the NodeMCU ESP32 with the mobile application. With this system, it is expected that the time taken for recording student attendance will be reduced. In addition, the number of students inside the class can be viewed all the time without head counting. Future improvement is needed to improve the functionality and features of this system.

Acknowledgment

The project is supported by the School of Electrical Engineering, Universiti Teknologi Malaysia.

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Smart Attendance and Notify Me Apps

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Abstract: This paper discusses a project developed in Capstone Project 2020/2021-1 academic session. Our group implemented a smart school theme project "Smart Attendance and Notify Me Apps". Firstly, data collection to determine suitable app features was done by surveys given to targeted audiences. Secondly, required features are analysed and project prototype was developed. Finally, the final product was presented to an industry panel evaluators. The method, flow of works, analysis and detailed results are further discussed in this paper.

***Keywords*:** Attendance; OLED Display; Notifications; Fingerprint Sensor R307.

Introduction

For the capstone project, the theme given was smart school system. From this theme, our group decided to implement the smart school system in our project. The smart school, as espoused by Malaysian government, is a learning institution that has been systemically reinvented in terms of teaching-learning practices and school management in order to prepare children for the Information Age. However, many schools in Malaysia are still new to this "SMART" concept to be applied in their organization. Our project aims to make schools to be more advanced with technology utilizing IoT features to ease daily routine at school. We found that the most severe problems faced by most schools are management of school attendance and dissemination of school notifications. Our project did not focus on the teaching and learning methods because they are in optimum phase in most schools. Most schools have electronic devices with aid of government plans in order to make smart learning and teaching process.

Smart attendance system and notification app is the solution we proposed in order as a step toward innovative management in school with IoT application. These ideas were obtained after we did research on the attendance and notification system used in most schools today in Malaysia. Our project prototyped a smart attendance device with a display to be installed in the classroom. The device and display are connected with a cloud service. The prototype app is for teachers where they can remind students and notify any update on school event. Notification information will be showed at the display in classroom with aid of cloud service. The attendance data will also be shown in the app. The app prototype was developed with considerations on social, technological, economical, environmental and political concerns.

In terms of social, research shows that almost 60% of today's schools in Malaysia lack social bonding between student and teachers. Social interaction plays an important role in learning. Interacting with other people has proven to be quite effective in assisting the learner to organize their thoughts, reflect on their understanding, and find gaps in their reasoning. The teacher must keep in touch with students to engage with learning process and update student progress. Hence, introduction of the notification app for teachers may help them to interact with students at all times and gives instruction and notification through the app in a short period of time.

For the technological aspect, we applied innovation in attendance system in school by using electronic device with IoT application. Logbooks and paper sheets are manual ways to take attendance for students by teacher for record purpose but these methods are poor in keeping the data and analysing it. Thus this smart attendance implementation help schools to be more "SMART" and have quality system.

Usually, teacher takes attendance with books or sheet provided by school management. Thus, the expense for the book for attendance are quite high with large number of classes in schools. In order to reduce the expenses, this smart attendance system records all attendance at internet cloud service, which are connected with the app installed by teachers. Thus it avoids the expenditure for the attendance books and reduce cost for the schools. The device is considered cheap with only a few electronic components. Hence, every school should be able to own the device to be installed at the classes.

For environment aspects, the device is pollution free and it applies go green concept. This proposed idea helps to reduce the paper usage for the books for the attendance system. Moreover, it is safe to be used by students at schools.

Politically, most schools at Malaysia use manual method to record administration and management data, which is paper records. It is hard for the school administrators to check and sort out the data especially attendance records. The proposed design applies smart theme where it uses online platform to store data. Apart from that, the notification feature of the app also helps teachers to inform students about events to be held and to send reminders to students.With the above aspects, the proposed idea was finalized and continued with deeper data collection and research on the related requirements.

Conceive-Design-Implement-Operate Approach

Conceiving

Based on the proposed design, a survey was conducted to identify the crucial problem related to our theme which is smart attendance system and notify app. It also enabled us to know the problem more deeply. The method we used to collect data for survey is through a questionnaire that was distributed to public, focusing on teachers and students in vicinity of local area. Basically, the users for our project are both students and teachers.Thus, several questions were developed in order to identify problems and how they affect them. Online platform was used to spread the questionnaire to get more feedback. The questions asked for both students and teachers are shown below;

1. How about the quality of attendance system before?
2. Is attendance at school still taken manually by teachers?
3. If not, state the method used at school to take the students attendance.
4. What is the fault that usually happens when taking attendance by a teacher?
5. Are there any smart features installed in the school classroom?
6. Is the school Internet connection good enough for active and passive learning?
7. How much time do average teachers require to walk to their classes everyday?
8. What is method used by teachers to inform their students if there is new task for them during school hours?
9. Your opinion on the current announcement method at schools?

From the questionnaire distributed, a total of 47 individuals responded including teachers and students. The percentage of teacher and student respondents is shown in Figure 1.

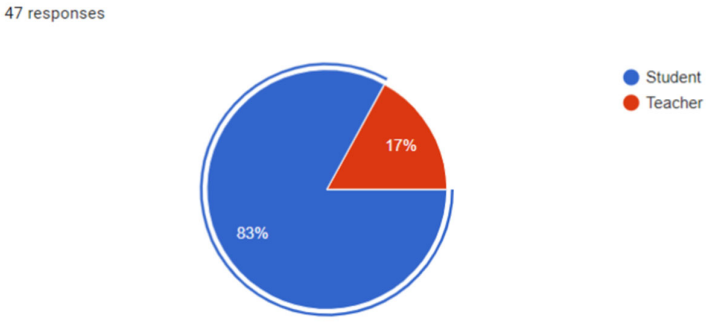

Figure 1: Pie chart of total number of respondents to our survey

Data clustering

From the conducted survey, the data collected from the questionnaire was analysed and interpreted. The interpreted data was used to identify the crucial problems and the corresponding solutions to the problems. Responses to questionnaire enquiries are analysed in Figures 2 – 5. Figure 2 shows that almost half of respondents were not satisfied with the current attendance taking system by teachers at school. Figure 3 indicates the percentage of smart classroom features at respondent schools were low at only 11%.

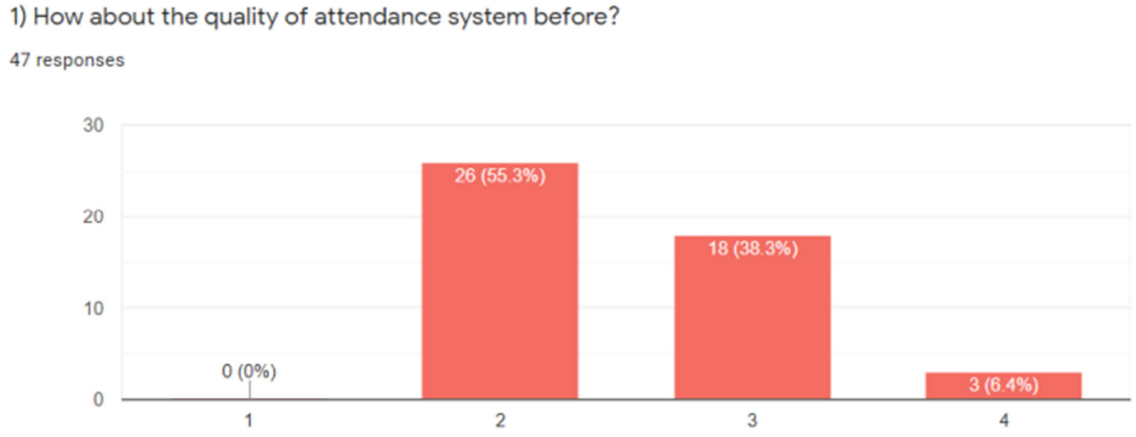

Figure 2: Responses on the quality of attendance system at school

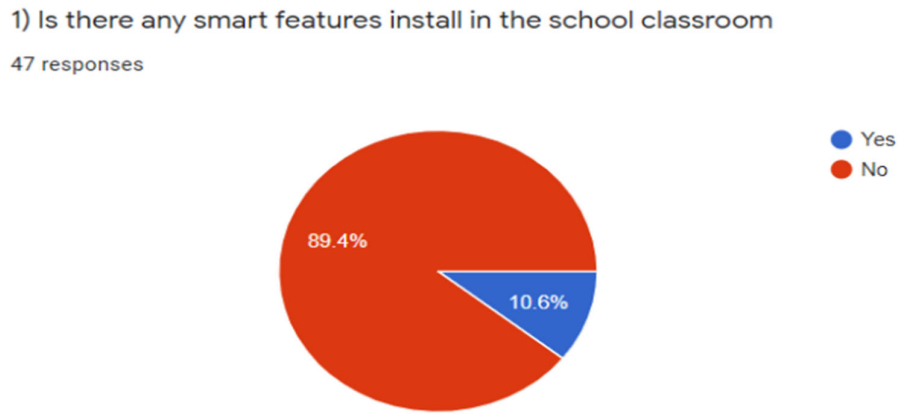

Figure 3: Pie chart on the smart feature installation at classes

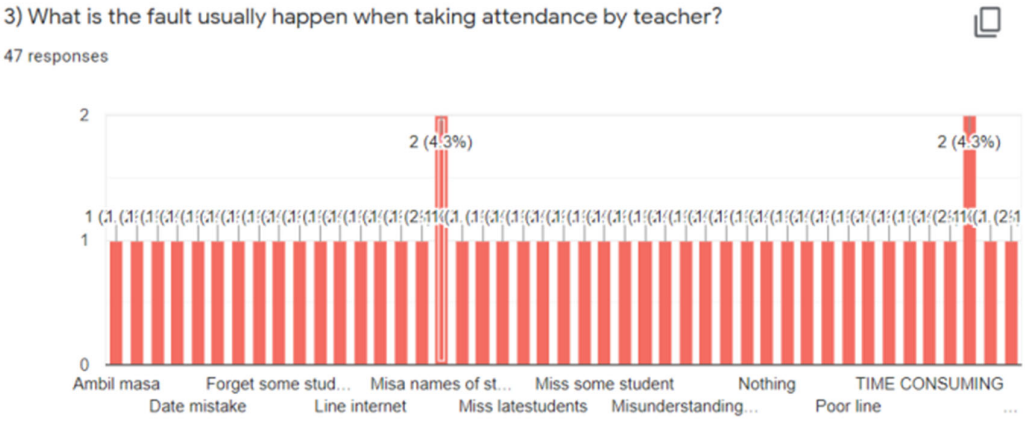

Figure 4: Feedback for inadequacy of attendance system in school

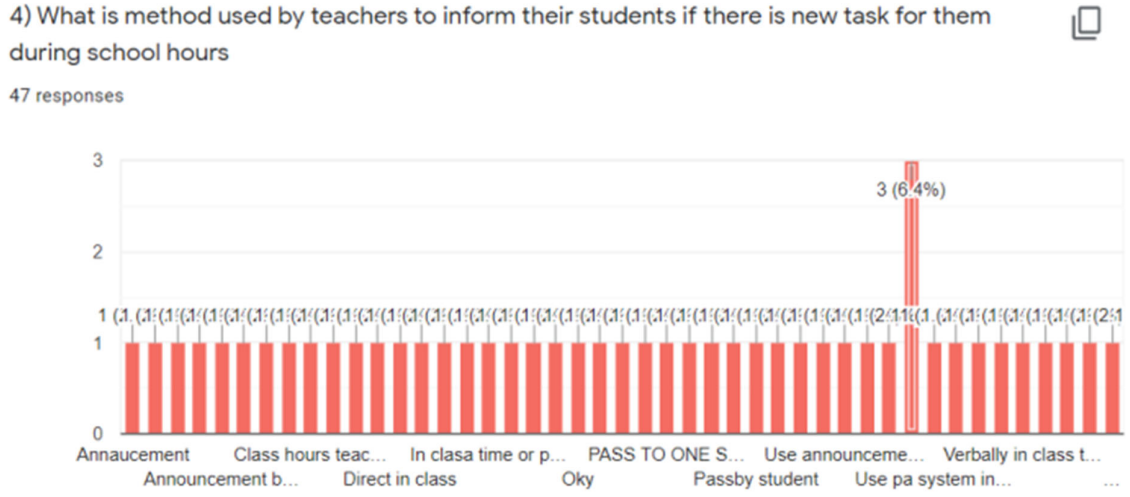

Figure 5: Feedback for method used to inform students by teachers at school

Figure 4 indicates the most common mistake made in current school attendance system was incomplete student list where name of student who actually attended class was missing and the process of taking attendance took too much time. This proves that the current attendance system is not effective to collect the data. Figure 5 shows that the most popular method used by teachers to inform student during school hours is to use announcement board. This method limits ability to reach all students and the information may take a long time to reach students.

The survey found that most students were not satisfied with the current attendance taking system and it is lacking smart classroom concept. Apart from that, the method used by teachers to notify students was poor. From survey, we implemented a smart attendance system and notify app with the theme of smart school.

App Design

The design was divided into two parts: software design and hardware implementation.

1. *Software Design*

We divided the menu options for the app into two options at the start of the application view as shown in Figure 6. One menu is for students and the other menu is for teachers. We designed the menus as simple as possible to make it easier for students and teachers to access this app. There are three features created for teachers, as shown in Figure 7. The main feature is to send a message to a class. The other features are a calendar and a time table, where a teacher can set reminders, and upload the time table that they have. The software block diagram for designing the teacher sub-menu is shown in Figure 8. The student sub-menu is used by students to see notifications sent by teachers.

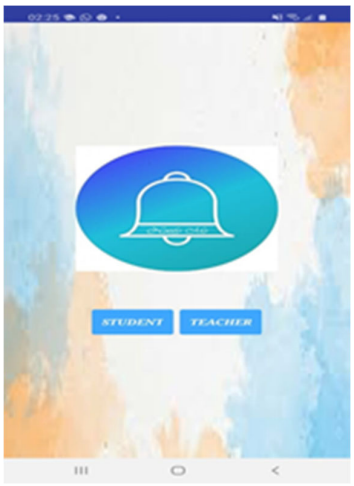

Figure 6: Starting view of app

Figure 7: Teacher menu

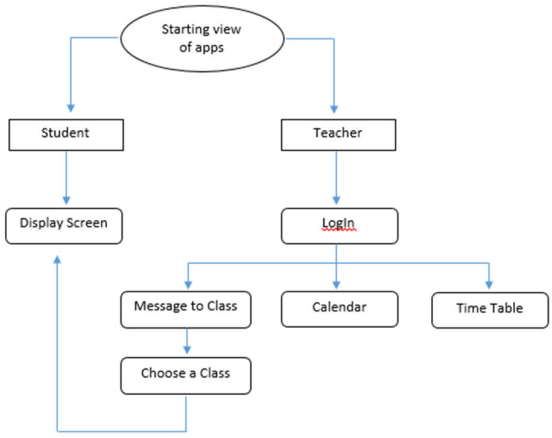

Figure 8: Software block diagram

2. *Hardware Implementation*

The hardware consists the Arduino compatible processor ESP32 system together with R307 fingerprint sensor and OLED display. Students register their attendance via the fingerprint sensor. All teacher notifications are displayed on the OLED display. The prototype used only a small size display. For actual installation, a much bigger display should be utilized. The power supply to ESP32 processor is provided through a 9 V battery and a voltage regulator. The hardware prototype is shown in Figure 9. The hardware part was not 100% successfully implemented because the fingerprint detection algorithm did not work sometimes.

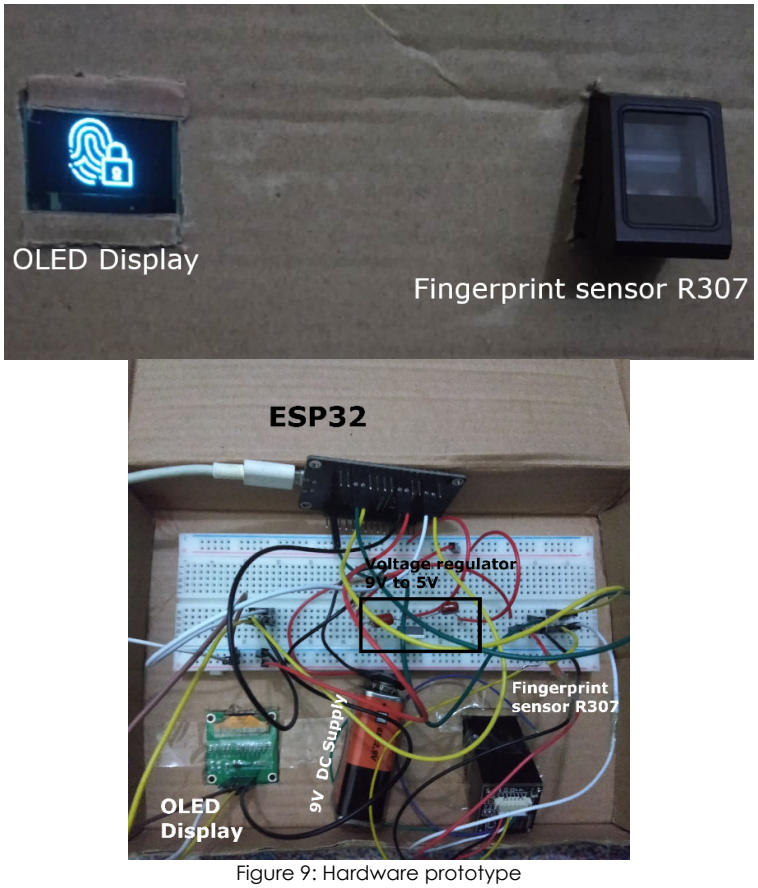

Figure 9: Hardware prototype

Table 1: Connection for ESP32 pins relative to standard Arduino pins

Arduino Mega Pin Number	Component Pin
SDA	RTC SDA
SCL	RTC SCL
TX	WIFI RX
RX	WIFI TX
D2	PWM of Servo 1
D8	Signal to relay

App Operation

To use the developed app, first user needs to install the Notify Me app on two devices, namely, on the display device that is placed in front of the class and the second on the device of the teacher. The display device will be connected to the smart attendance hardware where the finger print sensor is used as an attendance detection device. The hardware will be connected to the Notify Me app, which records and monitor students who attend class for the teacher. Besides that, a teacher can also give messages to students by simply typing through the Notify Me app that has been installed on the smartphone. Information to students will be displayed on the display screen installed in front of the class.

Result and Analysis

This project was successfully designed to improve students attendance system for teachers and as better communication tool for teachers using smartphone app. This prototype system will reduce time and effort for teachers to do their daily tasks. The system also helps students to know updates about their classes faster and take action accordingly. This system will contribute to an efficient management system in most schools. In summary, the benefits of the prototype system are:

- A fingerprint sensor was used to replace manual attendance system done by teachers before. Time taken for taking students attendance can be reduced and recorded attendance can be obtained in the database.
- Teachers can choose a class to send their latest information quickly and the information will be directly displayed in a particular class.
- A teacher can manage other information such as calendar remark and change timetable.

Innovation

This project was developed through some innovations and improvements. This smart system will help educators to save time and make their tasks easier. There are many available softwares that can be used to deliver messages but Notify Me app was developed to focus on the educational purpose and limit the functions to teachers and students only. In the real situation, students can only access the notifications and the attendance. The database can only be assessed by teachers. In schools, students are not allowed to bring smartphones. However, teachers can use a smartphone to send messages to students in a classroom quickly. With this invention, the communication between teachers and students in school can be improved. This system helps teachers especially when they are in an emergency and cannot teach a class. Delivering a fast message will give information to students rather than leaving class without a teacher.

To conclude, we need to implement this system in most schools and improve the available system. Up to date, the traditional system is good for implementation but with further improvement will make learning and teaching sessions better.

Conclusion

Our hardware prototype cannot work properly because of the problem regarding fingerprint identification while our software application can work as expected. We also need to improve the database system so it will be more systematic. Improvement can be made to make sure this product more competitive and able to compete with similar products.

Acknowledgement

The project was supported by the School of Electrical Engineering, Universiti Teknologi Malaysia. Our facilitator Assoc. Prof. Dr. Nasir Shaikh Husin supported and supervised this project for 13 weeks to complete our capstone project. We also want to thank our Division of Electronic and Computer Engineering coordinator, Dr Suhana Binti Mohamed Sultan for her lead in the capstone project. We also would like to thank our panels during presentations and our friends that were involved while completing our project.

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Smart School System

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Abstract: This paper focuses mainly on the smart school system. Smart school technology will bring a lot of benefits to the students as well as the school management. The technology in managing the school facilities and security to provide more efficient and safer learning environment for students will be discussed.

Keywords: smart school system; school facilities; security

Introduction

These days, school districts face several challenges to maintaining energy-efficient facilities while providing a safe and healthy learning environment. Among these challenges are:

- constantly-changing student needs
- security issues
- increased energy use
- aging physical infrastructure and deferred maintenance needs
- budgetary strain

Basically, schools are getting limited budget every year. High efficiency on energy usage can help free up resources by spending less on utility bills and have more money available for teachers, students, and classrooms. [1]. Studies have found that a better physical environment contributes to increase learning and productivity of the students. Previous research emphasized that we have to pay more attention to the quality of the school's environment as well as the problems of the schools' energy consumption.[2] Based on their analysis, the heating energy consumption and electrical energy consumption are the main directions that should be concerned about. It means that the energy consumption intensity of school buildings is relatively smaller, but the total energy consumption is large.

Furthermore, the schools which is an open system, are easily exposed to all kind of security threads coming from inside and outside of the school environment. In foreign countries, there is an escalation in the attacks towards students and teachers. Some of these attacks were resulted with severe wounds and even deaths. Beside these, theft, robbery, bullying, destroying the school goods are common events and the school management generally is difficult to handle these problems.[3] This indicates that the schools are not well prepared for preventing and solving security problems.[4]

Later, we will discuss about the technology that we used in order to assist school management to deal adequately with the stated problems.

Conceive-Design-Implement-Operate Approach

Conceiving

Due to the COVID 19 pandemic, we conducted a survey online using Google Form. We prepared 10 questions for the online survey.

Data Analysis

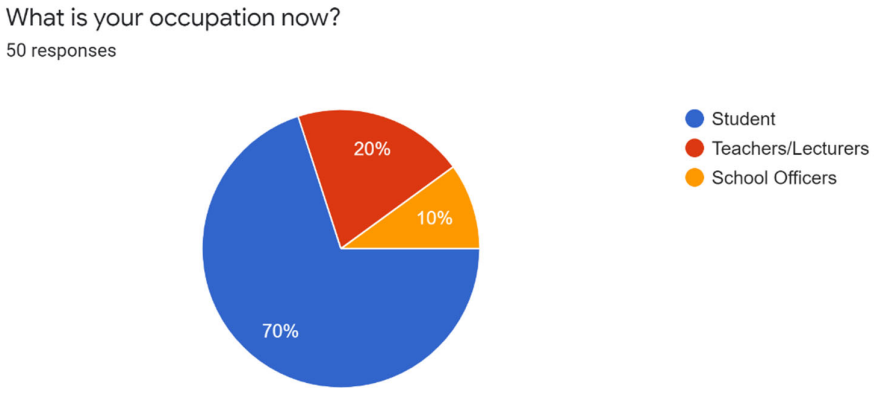

Figure 1

We managed to obtain 50 responses via our online survey. Based on Figure 1, there are 70% of respondents are students while another 30% are teachers and school officers.

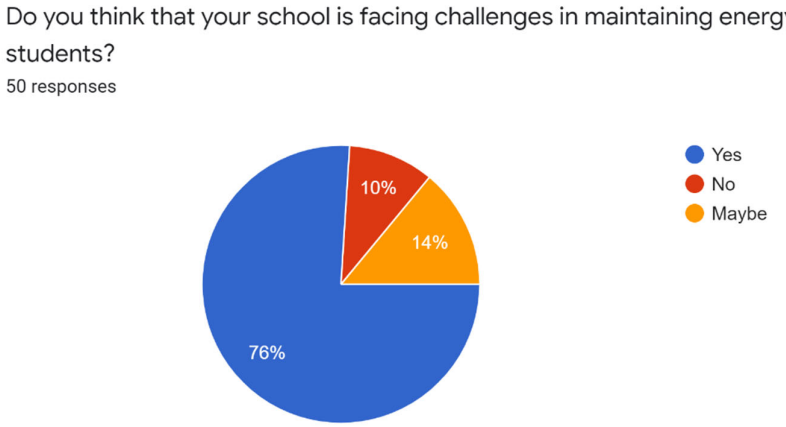

Figure 2

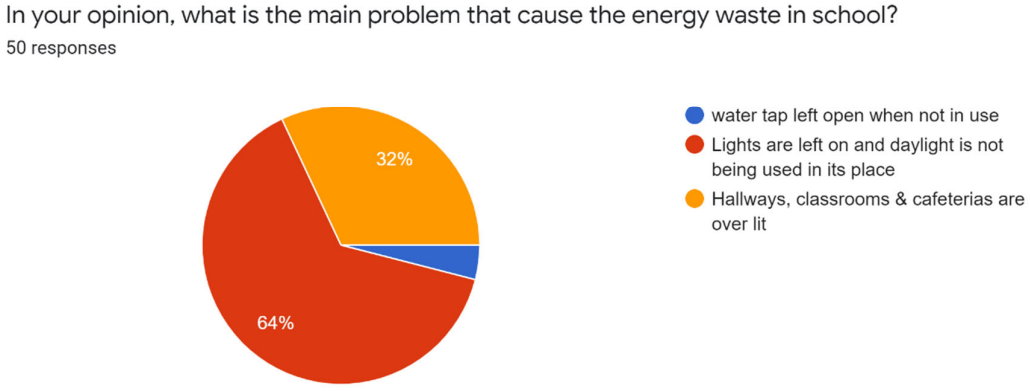

Figure 3

Based on Figure 2, most of the respondents think that their schools unable to maintain energy-efficient facilities for them. Moreover, lighting contributes nearly 50% of the electric bill in most schools [2] and we found that the main problem that cause the energy waste in schools is lighting issue. Figure 3 shows that there are approximately 64% of respondents think that lights are left on in unoccupied rooms while about 32% think that some places in school likes hallways, classrooms or cafeterias are over lit.

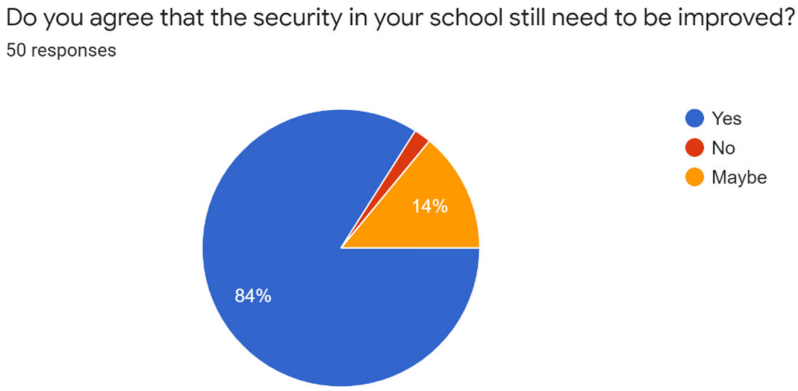

Figure 4

Based on Figure 4, there are about 84% respondents agree that security of their schools still need to be improved. This shows that the security of their schools is still a great concern for them because a safe and secure environment is a prerequisite for effective teaching and learning. Furthermore, we also had a brief phone interview with Miss Halimah, who is a teacher at SMK Taman Sea in Petaling Jaya. She found that many lights are left on when the classrooms are not in used. This caused the energy waste problem in her school. She also received a lot of complaint regarding the security issues of her school. There is not enough manpower for the patrol in the school areas. Hence, she worried that outsider will break into the school area easily through the back gate.

Design Statement

How can we help the school management to reduce energy waste and improve the security of the school?

Objective

After we analysed all the extracted data, we decided to develop a smart school system using several sensors and a mobile IOT application. This is the main objective of our project to solve the energy waste and security problems.

Designing

We decided to use a few sensors which is light sensor, motion sensor and ultrasonic sensor to fulfil the objectives of the project. Besides that, Arduino UNO is used as the microcontroller of the whole system. Moreover, we decided to use the most popular IOT platform, Blynk which can connect our devices to the cloud in order to monitor and control our system through mobile phone. Most importantly, Blynk provides open-source Blynk Cloud. Therefore, it is cost-effective and suitable for education purposes.

Table 1 shows the STEEP analysis that is considered when designing the project prototype. All 5 sectors from the STEEP were considered and fulfilled with the help of information research through internet.

Table 1

Sector	Consideration
Social	Form a new culture in maintaining energy-efficient facilities and safe learning environment for student
Technology	The technology used in both systems utilized the technology knowledge in electronics field.
Economic	Reduce utility bills of school
Environment	The systems are environment friendly and no chemicals used by the system.
Politic	Reduce the possibility of illegal activities like school break-in.

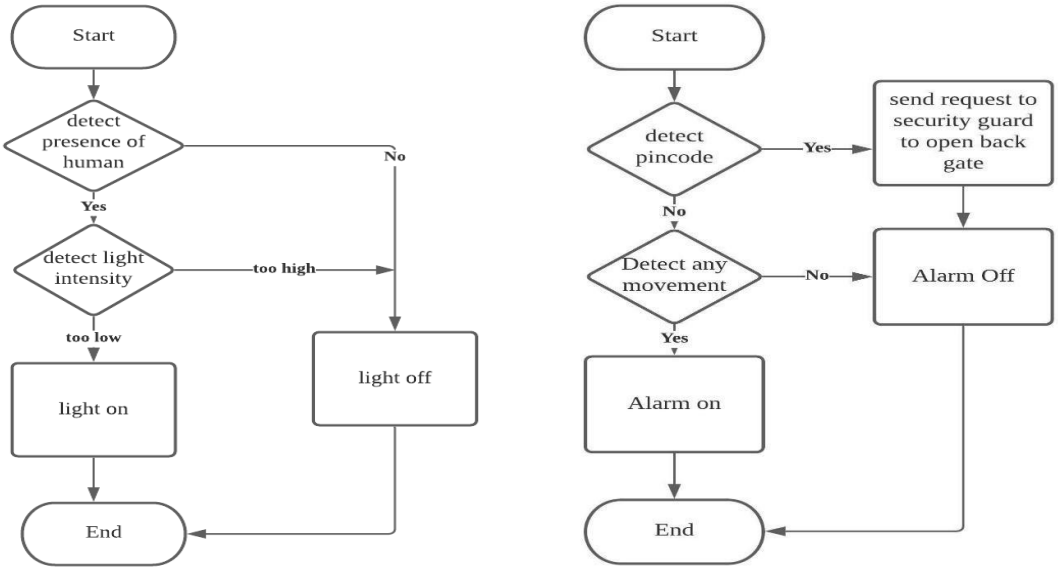

Figure 5: System Flow Chart

Figure 5 is the basic flowchart of our system. Basically, there are 2 parts in our system which is energy saving and security alert system. Both parts are controlled by a centralized server which is Blynk.

The list below are the important scopes for our project:

- ultrasonic sensor HC-SR04 is used in our prototype to act as an occupancy sensor. If human is detected, it indicates that there is presence of human in the room.
- The system will continue to detect the light intensity using light dependent resistor (LDR). If the light intensity is too high, the LEDs will automatically turn off.
- If there is presence of human, we can control the LEDs remotely using our mobile phone app, Blynk. If no one detected, all the LEDs will turn off.
- Use Blynk to key in pin code. If correct pin code is detected by the system, it will send a request or notification to the security guard's mobile phone to open the back gate of the school. Besides that, buzzer will turn off.
- If any movement is detected by the PIR motion sensor, the buzzer will turn on.

a) b) c)

Figure 6: a) LDR b) PIR motion sensor c) Ultrasonic sensor HC-SR04

The schematic for the circuit designed is shown in Figure 7.

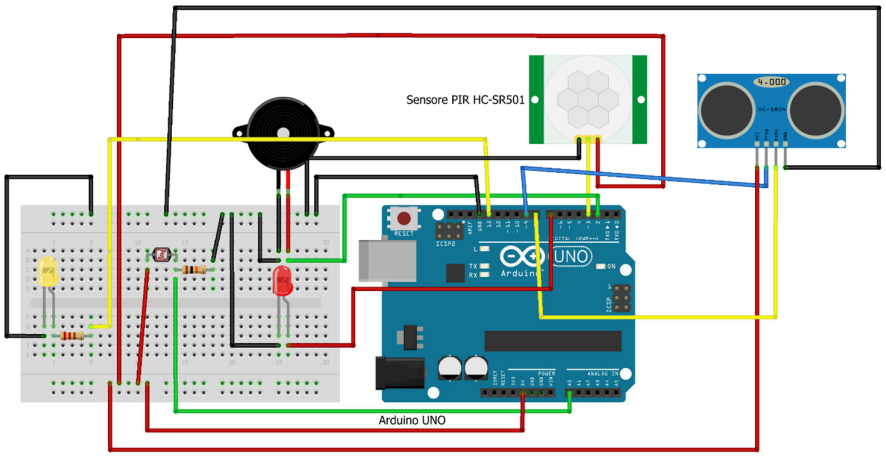

Figure 7: Schematic Diagram of Circuit

Figure 8 is the final prototype of our project. Basically, it is not a product but we considered it as a conceptual model of our project. We build a simple box to represent the school or a classroom in school. LEDs will represent the light and the buzzer will act as an alarm. The motion sensor is placed at the back of the box which represent the back gate of the school. Due to limited budget, we use this simple model to verify the output.

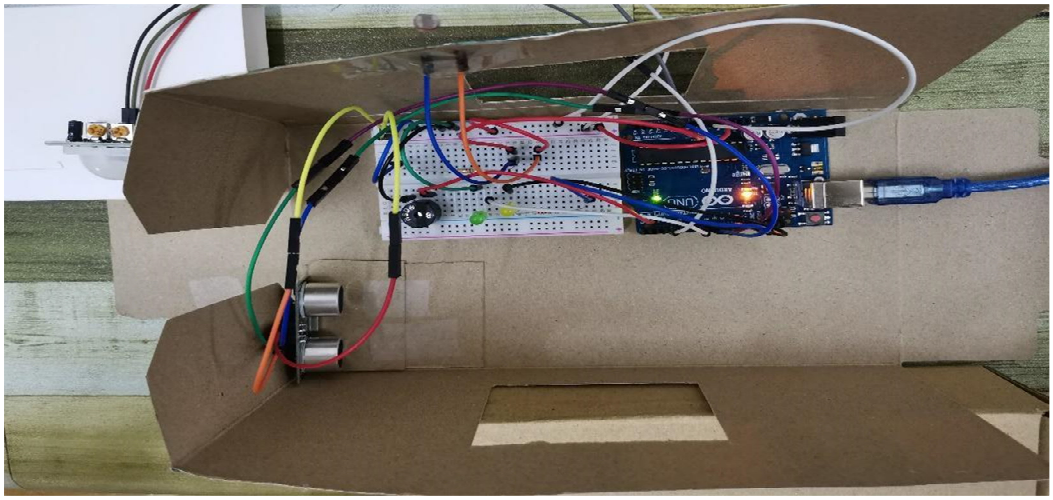

Figure 8: Final Model/ Prototype

Implementing

The implementation of the system into the realization is the assembling of all the components with the reference of previous schematic designed. The coding is uploaded to the Arduino Uno via the Arduino IDE and the circuit is tested to make sure it is working as intended. Troubleshooting process is done when the malfunction of circuit occurred and the problem is usually software problem rather than connection problem.
The connection of the Arduino Uno pins is shown in Table 2.

Table 2

Arduino UNO Pin	Components Pin
2	buzzer
3	motion sensor
7	LED
8	Echo pin of ultrasonic sensor
9	Trig pin of ultrasonic sensor
A0	LDR
V0	button1
V4	button 2

V3	pin code inserts
V1	virtual LED 1 on app
V5	light intensity gauge on app
V6	virtual LED 2 on app

Operating

Firstly, we will discuss about the first part of the smart school system which is energy saving. Based on Figure 9, we can see that there are a few components on the interface of the app. It includes 2 buttons for LED (V0 & V4), 2 virtual LED and 1 light intensity gauge. Basically, the microcontroller is connected to the mobile phone via Blynk server. When the ultrasonic sensor detects someone at the distance more than certain range, **it means the person is not inside the classroom.** Therefore, all the light (LEDs) are always off and cannot be manually switched on by buttons. If someone is detected inside the classroom, light will turn on based on the light intensity of the room. In our model, if the light intensity is less than 10, LED 1 will turn on; **if light intensity is too low (less than 6), both LEDs will turn on.** Moreover, we can manually control our light (LEDs) remotely using the buttons on app if the light intensity is high. **In other words, the light will automatically turn on when someone is inside the room and the light intensity is too low.** The app interface of energy saving for smart school system is depicted in Figure 9.

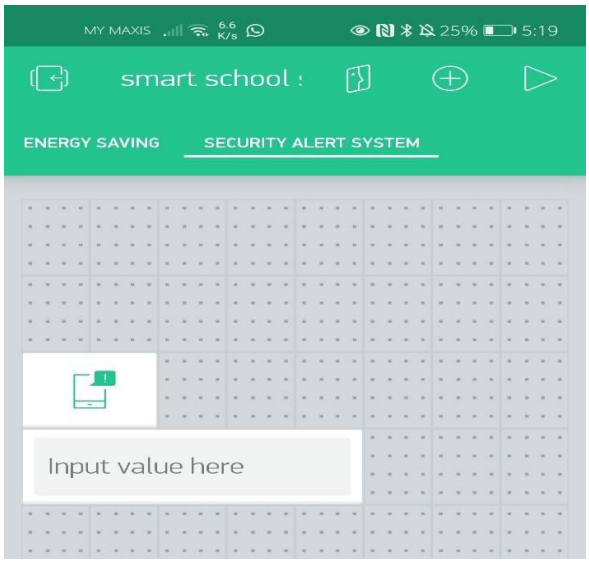

Figure 9: Apps Interface

Next, we will discuss about the second part which is security alert system. If the motion sensor detects any movement at the back gate, **it will send notification to alert the security guard and the alarm(buzzer) will turn on.** However, if we insert correct pin code in our phone, the alarm will not turn on. Security guard will get the request from the system and open the back gate. The app interface of security alert for smart school system is depicted in Figure 10.

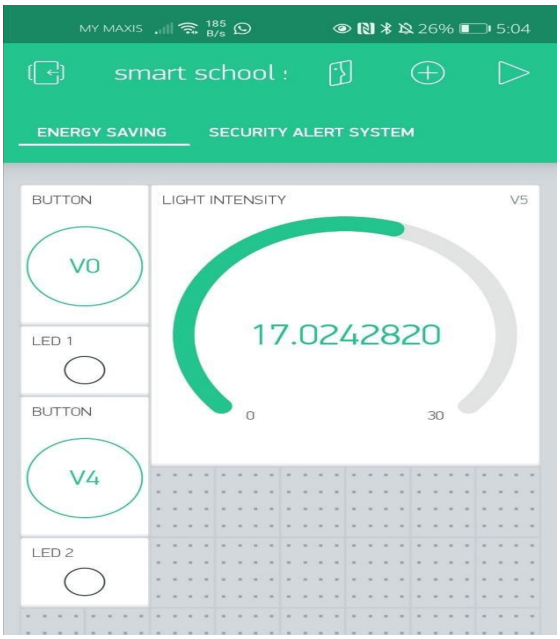

Figure 10: Apps Interface

Result and Analysis

In this project, the system is functioning very well without any problem. After we run the system using our model, we successfully obtain the desired output. This indicates that the lights will automatically turn off when the light intensity is too high and no one is using the room. Hence, this system can help the school management to **manage the energy usage of the school in more efficient way** which means less energy waste and reduce the utility bills of the school.

Furthermore, children have little control over the environment surrounding them as it is getting more challenging. They must depend on adults to keep them safe and enable them to endure various kinds of risks. [5] As we know, safety is one of the primary duties of a security officer. Patrolling is one of the most important features in security. It optimizes the important and costly human resource. Our system is able to monitor the surrounding of the school back gate and turn on the alarm if any stranger tries to break into school through back gate. Hence, our system can reduce the manpower which means it is not necessary to have someone guard at the back gate of the school. **In other words, the security guards can pay more attention in patrolling the whole school surrounding.** With this system, security issues will be reduced and the safety of our students will be secured.

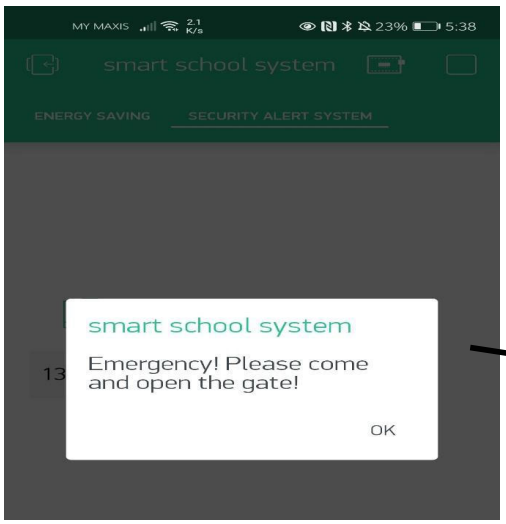

Figure 11 shows the security guard receive a notification from the system if the school staffs have to use the back gate of the school. The school staffs have to key in correct pin code to send this message to the security guard.

Figure 11: How Notification is Received

Innovation and Future Works

This system is still rarely applied in primary or secondary schools. We refer smart home concept which means we control all the lighting and the security of the school in a centralized system via IOT platform. This is considered as the innovation we do in this project. However, the model in our project is just a basic idea or concept for future works. The sensors we used is not suitable for a large school area. For examples, Omron Electronics D6T MEMS Thermal Sensor is a more powerful and suitable occupancy sensor for the smart school system. It is able to detect the presence of stationary humans by detecting body heat, and can therefore be used to automatically switch off unnecessary lighting, air conditioning, etc. when people are not present. It can detect larger area and is very useful in energy saving for the school. Due to its high cost, we only use the basic ultrasonic sensor to act as the occupancy sensor to detect presence of human in our model. Moreover, a more powerful controller is needed to control all the sensors throughout the school area. We really hope that a successful and excellent smart school system is able to be applied in school one day.

Conclusion

Our model worked successfully. All the sensors can operate as expected and perform stable result. However, we encountered some problem mechanically and technically. Eventually, we are able to solve the problems and completed the project.

Acknowledgement

The project is supported by School of Electrical Engineering, Universiti Teknologi Malaysia. The authors would also like to convey our utmost appreciation and gratitude to our supervisor Mr Camallil bin Omar and all the teammates for the completion of this project.

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Smart Biometric Cashless System

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ABSTRACT: In this paper, we discuss the development of an e-Wallet to be applied in a smart school cashless system. The system aims to assist parents and school administrators monitor pupils' financial expenses in school. We propose a smart biometric cashless system using a novel integration of NodeMCU and ThingSpeak cloud database framework which utilises a fingerprint scanner and is able to provide instantaneous notification to parents of the purchases made by their children. The information encompasses amount deduction, account balance, and transaction history. A demonstration of the system prototype verifies the feasibility of our system as a basis for future solutions.

Keywords: NodeMCU; ThingSpeak; e-Wallet; smart biometric; cashless system.

Introduction

E-wallet is a type of pre-paid account in which a user can store their money for any future online transaction. An E-wallet is protected with a password. With the help of an E-wallet, one can make payments for others people transaction. E wallet has mainly two components, software and Misnon information. The software component stores personal information and provides security and encryption of the data. The information component is a database of details provided by the user which includes the top up transaction, amount to be paid and credit or debit card details. Most of the E-wallet are mainly focus on online shopping. In conjunction with this technology, an E-wallet for school students is introduce to control their expenses during school period and reduce the bullying cases. Bring to much money would be a problem for school students as bullying still occur among them. One of the other issues is they cannot manage their money very well and keep on spending too much om inappropriate things. By using e-wallet technology, their parents can monitor the transaction via software application. In this project, an e-wallet NodeMCU based has been built for school students with fingerprint sensor as the input to alert the software apps user that a transaction has been made.

Objective

The objectives of this project is to detect students spending in school so that the parents can know what and where did their children spend money as well as limiting the amount money that their children might be overly spend. Besides, it is one of the ways to teach their children about the importance of managing finances without spending on necessary things. Parents can also monitor their children's expenses.

Survey findings

A survey has been carried out to identify which area of smart technologies in education system should be implement. In Figure 1, There were a total of 54 responses who fill out the survey using google form.

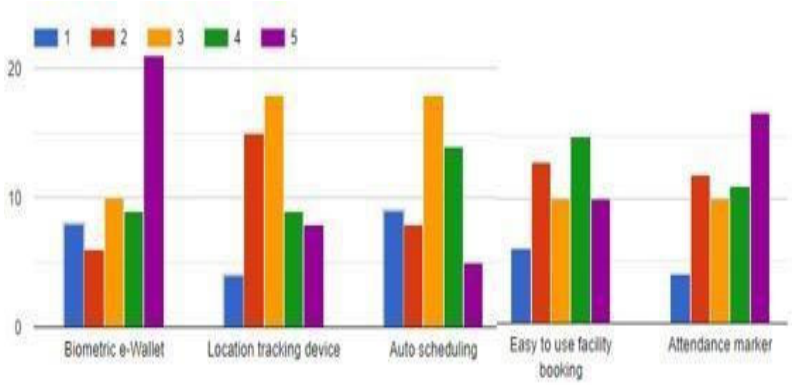

Figure 1: Chart of surveys

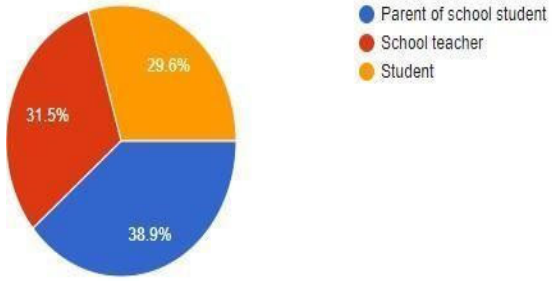

Figure 2: category of respondent

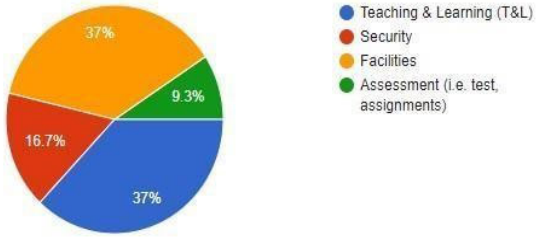

Figure 3: Areas in implementing smart technology

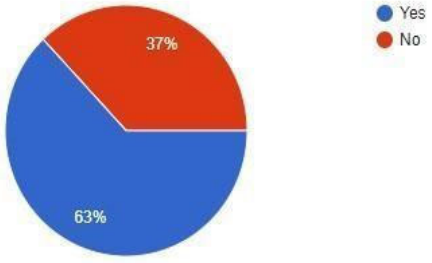

Figure 4: Experience of smart technologies

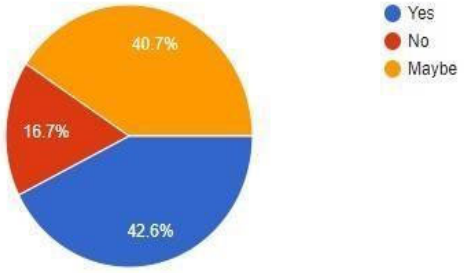

Figure 5: Relationship between students and in School teachers to be closer with smart technology

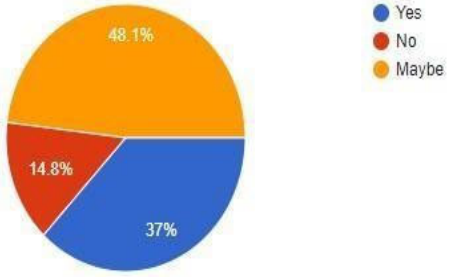

Figure 6: Opinion smart technologies can be fully implemented in school by next 10

Figure 2 shows that majority prefer biometric e-wallet should be implemented as it benefits them the most. In Figure 3, majority parents of the school student fill the form about (38.9%) followed by second highest category which are the teacher (31.3%) and the least respondent which is the student (29.6%). From Figure 4 and 5, it is stated that most of the respondent think that Facilities, Teaching and Learning (T&L) should be the areas that need to be improve (37%) and majority of them experienced smart education technology system (63%).

In Figure 5, the highest is that they believe that relationship between students and teachers can be closer with the use of smart technology with (42.6%). There is not much difference with the respondent were not sure of it (40.7%). From Figure 6, less than (14.8%) said no because they think school technology system cannot be implemented fully in the next ten years and nearly half of the respondent were not sure (48.1%).We also interviewed one of the teachers from SMK Sungai Baging primary school which is Puan Samza binti Muda at the age of 49 years teaching Chemistry and Science. Figure 7 shows the answer from Puan Samza.

Answer from interview

1. Primary school at rural area
2. Have been teaching about 12 years start from 2008
3. Challenges lack of facility, peer influence that leads to disciplinary issue
4. Yes there are a few smart technologies that ever had was attendance record using fingerprint
5. About the security, still
6. Yes, unsafe for students to bring a lot of cash to school especially when to pay for school fee, buy necessary items such as reference books and activities book.
7. Primary student have not matured enough to manage their financial and expense. They tend to spend all their pocket money. And bringing a lot of cash might be increase the theft problem among the student and there are a few cases where student loss their money during school session.
8. This case and problem can be avoiding and reduce if student doesn't need to bring any cash to school. If the school implement the cashless system, then it could be safer for student.
9. Suggestion for smart technology that can be used is a cashless system that every student have their own account and all the transaction use in canteen and bookshop are online transaction. It is also can monitor every single details of the money that student spend.

Figure 7: Answer from interview

Design statement

For the hardware part, the layout of the conceptual thoughts is sketched in Jamboard application. For conceptual design along with sketching the conceptual design, many of the concepts suggested are functional and useable but some of them were quite difficult to implement. Then, Final conceptual specification for the biometric cashless hardware have been merged together for students. The final conceptual product concepts for biometric cashless system have been sketched in Figure 8.

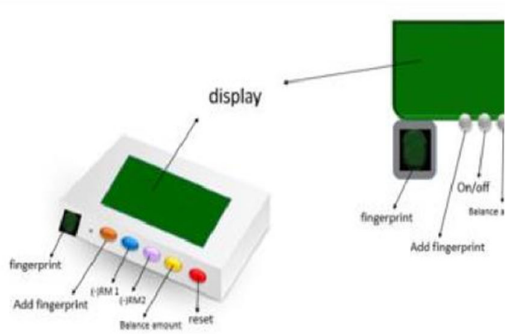

Figure 8: prototype sketching

Upon the sketch of conceptual design, a prototype was invented using Jamboard application as a main material. All necessary components included electronic parts required for the smart biometric cashless system were placed on the conceptual prototype. Below show the pictures of conceptual prototype for our system from the beginning of prototype.

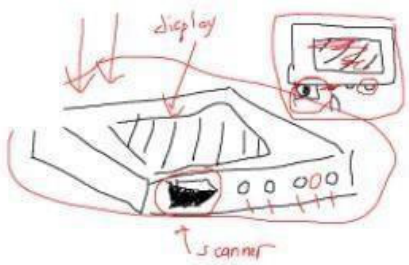

Figure 9: Hardware Sketching

The flow chart for system activity were designed. This flow chart shows the working flow of the system from the machine worked until it was disabled. This graph of flow is important as it makes it easier for us to understand how the system functions and simplifies, if necessary, troubleshooting work. Figure below show flowchart of the system of software and hardware.

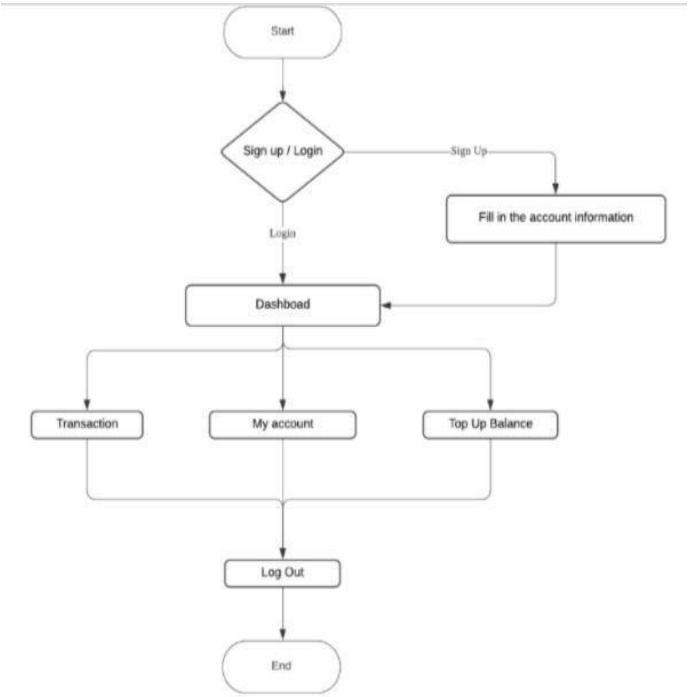

Figure 10: flowchart of software

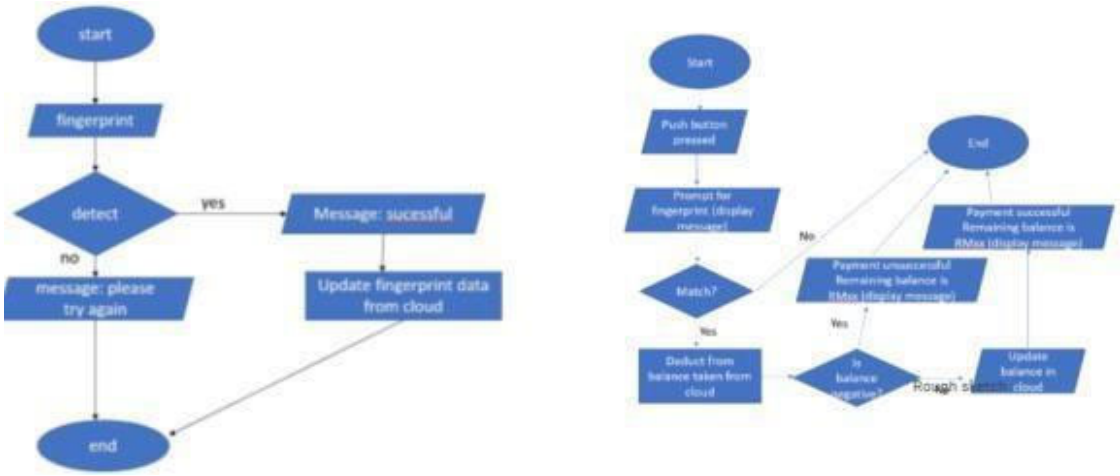

Figure11: Flowchart of hardware

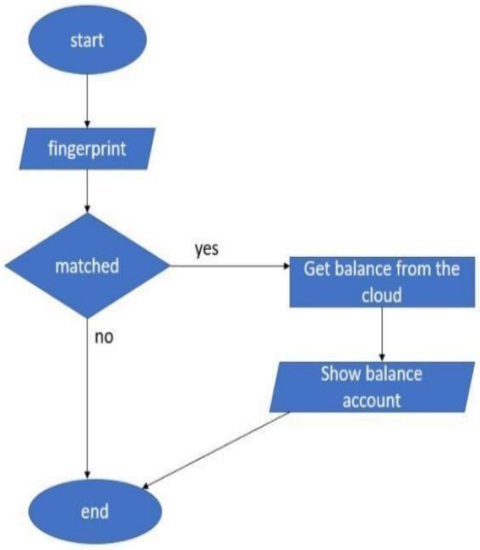

Figure 12: Flowchart of balance button from cloud database

System methodology

This project is split into two parts which is hardware and software. For the hardware approaches, it consists of NodeMCU ESP8266 as the microcontroller, a fingerprint sensor, the LCD display, 4 push button and LED indicators. The connection for these component is being embedded through a breadboard. The NodeMCU will be programmed via Arduino IDE and the result from the codes running will be display on the LCD display. The push button will act as a function depending on the needs such as deduction process. For the programming process, the main program is executed on Arduino IDE software by using several types of Arduino libraries. The code itself contain on how to read data from ThingSpeak, a control variable and the return code for HTTP. The LED also will light up according to the function programmed.

As for the software, the application is developed by using MIT App Inventor which can be use online. The software features are consisting of current balance account, transaction history and top-up account balance. The application is then will be link with ThingSpeak IoT cloud to store and read data. As being discuss before this, the NodeMCU will be connected to LCD display, push button and fingerprint sensor. The push button and LED indicators are embedded into the breadboard to send signal to the system. Since the LED is lights up, the system is ready to operate.

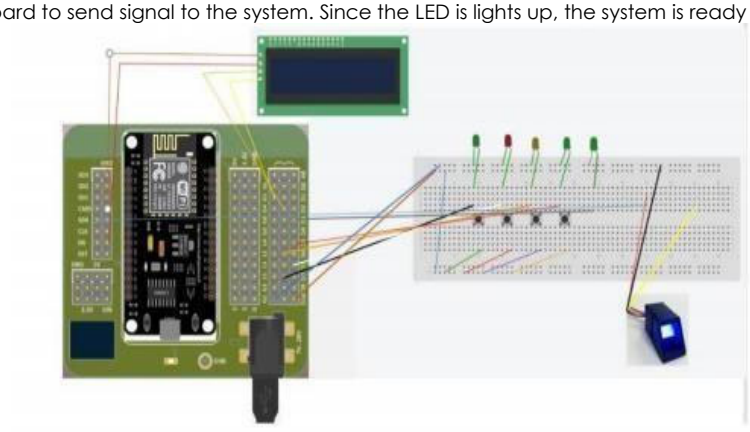

Figure13: Circuit diagram

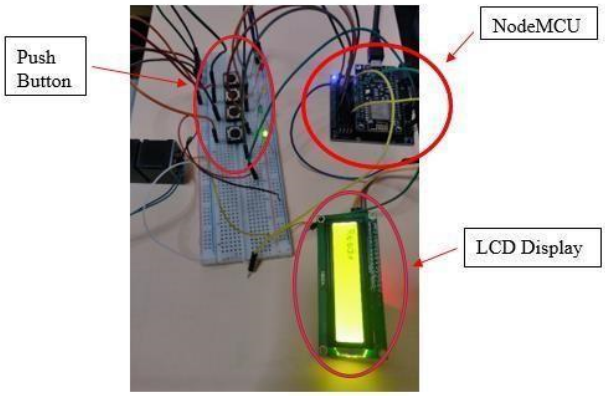

Figure 14: Hardware

Apart from that, the software will be features starting from login page, function button, total balance amount and top-up option. The user interface for each feature are shown in Figure 15:

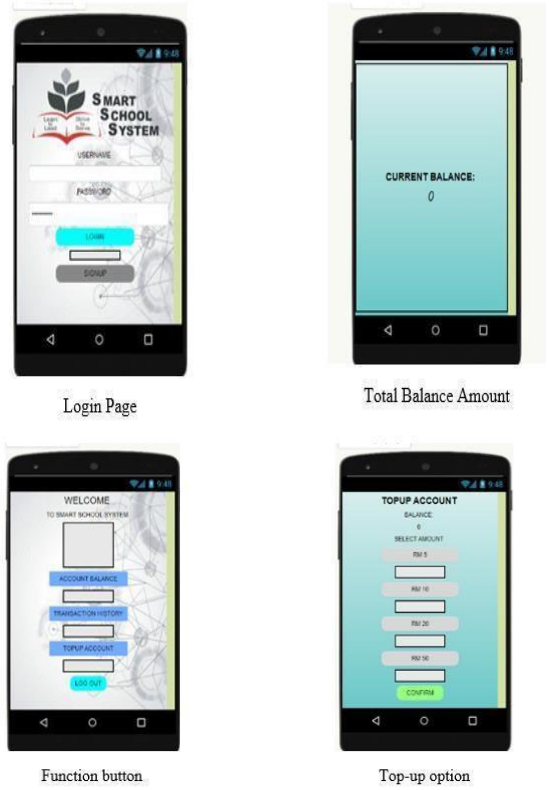

Figure 15: Software

Discussion and result

This smart biometric cashless system is allowed users to make a transaction by scanning the finger print and monitor their e- wallet with an application that developed by using MIT App Inventor. This application is link with the scanner device through ThingSpeak IoT to read and write the data. Basically, the function that have in this application are viewing the current balance account of each user and authorize users to top up their e-wallet account. For this project, two users have been created to test the functionality of the application and the data of each user will stored in the different field in ThingSpeak IoT. For the viewing current balance function, initialize the balance1 equal to zero and read the data value at field1 from the ThingSpeak by using API link provided and set back to the balance1.

For the top up function, there are several buttons amounts that provide to the user which is RM5, RM10, RM20 and RM50. Otherwise, user also have option to enter the preference amount to top up the ewallet account. The coding for this function is shown below. Basically, this function work by get the current value of each user from

ThingSpeak and do the addition operation based on the amount that choose by the user, then write the new value to the ThingSpeak IoT.Since the application is link with the ThingSpeak as the cloud to store the data, there are some limitation on this application such as not able to store the information data of the user because ThingSpeak only store the data integer. Hence, it is not really suitable to use to store multiple users for this application. For further exploration to improve this is by using other data base cloud system but it may need additional cost to subscribe the cloud system. Next, the other limitation security since it is does not have the verification function for top up the e-wallet account. This is due to the MIT App inventor does not have this feature. Even though this project is use ThingSpeak as cloud to store data and MIT App inventor to build the application, it is managed to be use as a biometry cashless system. For the hardware implementation, all of the proposed functions are working correctly. We also achieved multiple user function in the end, where we sought to do only one user when we started this project. Overall it was a success because we achieved this in a short amount of time. In the future, the hardware could be made with a casing to be more user friendly and easily moveable.

Conclusion

This smart biometric cashless system is able to perform feasibility study of the overly expenses among students and parents worrying about their children's spending. The final prototype is working properly as expected according to the proposed conceptual prototype although facing challenges in developing more than one user. Both Arduino and Android part in the project are working successfully on the final product. For future improvement, more user data can add, improve verification security of software and Navigation system (GPS) into the mobile application so that the parents or teachers knows the location of the children. Other than that, 3D of hardware should be implement.

Acknowledgement

We would like to thank everyone who have contributed both directly and indirectly towards finishing this project.

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Smart Library Management System

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Abstract: This paper is about the implementation of radio frequency identification (RFID) technology in the library management system of a secondary school in Malaysia. Based on the feedbacks from the questionnaire that we have distributed via social media, one of the current problems faced by the students is regarding their school's library management system as it is inefficient for both the students and time consuming. The students mostly rely on their school library for study materials such as references as well as exercises and to broaden their knowledge to be able to obtain good grades in their examination. Therefore, with the implementation of RFID technology, despite of improving data management, the borrowing and returning books can be speed up and thus ease the overall process of the students to obtain their study resources.

Keywords: RFID technology; library management system; automation; borrowing and returning process; data management

Introduction

Secondary students nowadays are highly dependent on their library as their primary source for knowledge and references to help them in their studies which can be proven based on the feedbacks that we have received from our data clustering and data analysis. This is further supported as the secondary school students are strictly prohibited from bringing their mobile phones to school. However, the students realized that they have spent an unnecessary a great amount of time whenever they decided to go to the library. This is due to a long queue at the counter for borrowing and returning process. The waiting time will be much longer if the librarian was not around because they rely on the librarian assistance because only, they have the access to the system. The main problem that needs to be solved is to create a smart library management system in which the students can self-check-in/check-out the books they need without having to rely on the librarian. Hence, the students can save their time. The solution that we have proposed to approach the problem is by using the RFID technology. For societal aspect, the implementation of this technology can ease the process of recording and storing the data of students borrowing and returning books and it is less time consuming. Meanwhile, for the technological aspect, the implementation of this technology has modernized in accordance to the country's development and increases automation in repetitive task. Economically, this new and improved system is a good investment for the school as it indirectly increases the school's performance and reputation. Plus, based on [1], RFID is cost effective as the price of individual tags reduces with volumes manufactures. Environmentally, it reduces the degradation of the environment as it reduces the usage of paper. Lastly, from political aspect, the privacy of the data stored is enhanced which strengthen the student's and the school's privacy.

Conceive-Design-Implement-Operate Approach

Conceiving

At the early stage of our project, we have developed a questionnaire to collect data regarding the current problems faced by the students, teachers of staffs in school. We distributed the questionnaire via social media applications as the current situation due to Covid-19 has hindered us to physically go for site visit. After a duration of 2 weeks, we closed the response for our questionnaire and start the process of data clustering and data analysis. In total, we have received 76 responses.

Based on data analysis, we have identified one of the main problems that is faced by the secondary school students which is their library management system. For instance, based on the questionnaire, most of the students spend majority of their time in the library and one of the difficulties that they faced in the aspect of learning and teaching process is lack of study materials and resources. For a secondary school student, most of their resource and study materials can be found in the school library as they have a fixed syllabus and the teachers would usually use the resources from the library as their teaching materials. Also, as shown in Appendix we have developed a user profile to help us approach the problem and solution better. The existing library system is not efficient as they need to wait in a long lime for their turn and they need to rely on the presence of a librarian to be able to proceed with the borrowing and returning process.

Based on the user profile that we have developed, the needs and problems that we have to fulfill is to create an E-source which is a system that can provide an easy access to study materials and an improved library management system that enables the students to borrow and return books at a faster rate and without having to rely

on the librarian. Thus, the design statement for our project is how to help the students to access resource easily and quickly.

Designing

We first design a prototype to solve the problem faced by student and teacher that study of material was lack and this prototype can help student to check whether the material can be found in library or being rent by another student. We also want let student can self-check in and out their book by themselves so that It will save both librarian and student time to handle this kind of stuff.

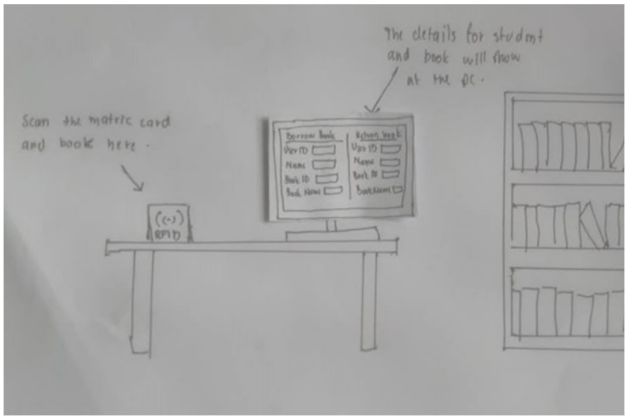


Figure 1: Concept sketch of smart library management system

Table 1: The STEEP analysis of the developed prototype.

Aspect	Discussion
Sociological	Nowadays, people are constantly racing against time. They would choose the least time-consuming way to complete a certain task while still maintaining an optimum performance.
Technological	Implementation of high technology to create a system that will cause a certain task and increased the work efficiency and performance.
Economic	Target primary/secondary schools that prioritize the convenience of their students/teachers/staffs and is also moving in the direction of improving the already existing school system.
Environmental	An environmentally friendly system as it reduces the usage of papers.
Political	Ensure that the information stored will be kept private between the student and the school and will not be exposed to any third party.

i. Only authorized people can access this smart library management system
ii. Data can be stored in excel synchronously.
iii. RFID tag must be detectable by RFID card reader.

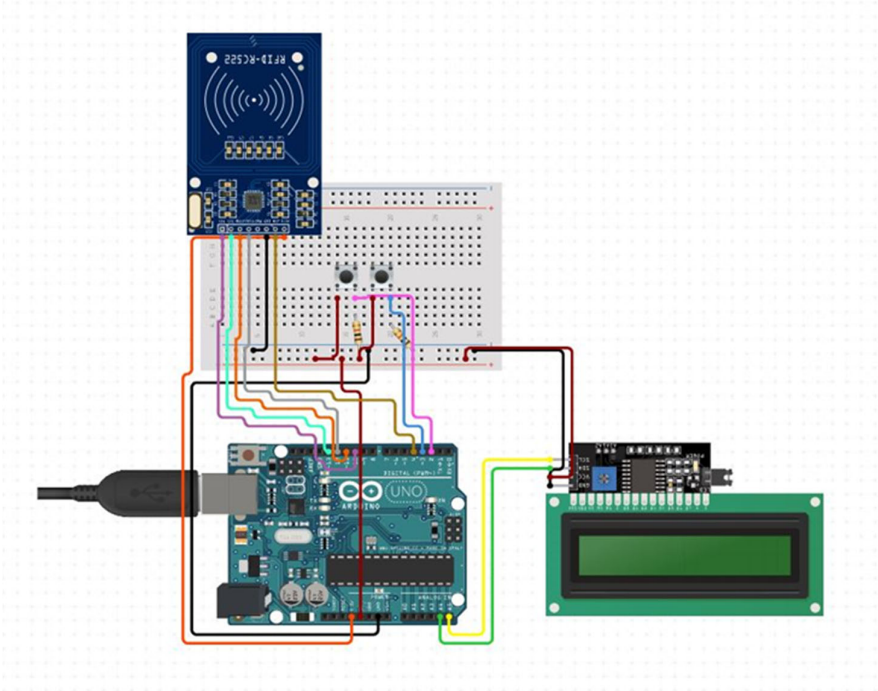


Figure 2: The schematic circuit for the system

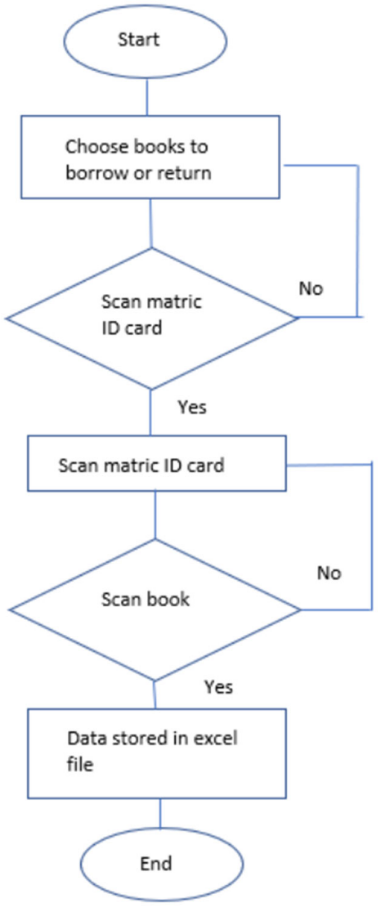


Figure 3: Flowchart of smart library management system (Discourage Mode)

For this project, we have a total of 11 meetings via Webex as this is the only platform for us to undergo discussion. The BOM is as shown in the Appendix. We held an online meeting twice a week for discussion purposes either to discuss new agendas or to continue the discussion on previous agendas related to our product development. In addition, we created a Gant Chart to help design, implement and operate the system successfully. The Gant Chart for out project is as shown in Appendix. The meetings and Gant Chart enable us to properly track and monitor our progress and ensure that we can finish the product within the timeframe that has been given to us. As a result, from the meetings, we can assign tasks to each member, generate, and discuss our ideas and state our thoughts and opinions regarding the project that we are developing.

UTM

SKEE 4723 CAPSTONE PROJECT
BILL OF MATERIAL (BOM)

SKE-4723-2020-10

Present the BOM to your supervisor to get it endorsed on Week 6. Finally, file it in the BOM folder in the Student Project File. Manually update the purchase and remark from week to week.

Signature (Student)

sia

Date: 10/12/2020

Checked by (Facilitator)

Date:

No	Component	Estimated Cost			Actual Cost	
		Unit Price (RM)	Qty.	Subtotal (RM)	Purchased Price (RM)	Delivery Week and Remark
1	Arduino	40	1	40	48.37	Week 8
2	I2C Liquid Crystal Displays	15	1	15	16.16	Week 8
3	Arduino Rfid card reader	8	1	8	11.86	Week 9
4	Arduino Ethernet Shield	22	1	22	26.66	Week 8
5	Petrol	20	1	20	20	
			Total	105	123.05	

Figure 4: BOM for the capstone

No	Tasks	Start Week	End Week	Capstone Week 5	6	7	8	9	10	11	12	13	14
1	Conceptual prototype presentation	5	5	■									
2	Preparation for Gantt Chart and BOM	5	6	■	■								
3	Finalize the components	7	7			■							
4	Circuit design and implementation	8	8				■						
5	Complete 2nd Individual report	9	9					■					
6	Programming (coding, testing and debugging)	10	11						■	■			
7	Hardware development	12	12								■		
8	Implementation and testing	13	13									■	
9	Finalization	14	14										■

Figure 5: Gantt Chart for the capstone

Implementing

We first bought the components online and manage to connect on breadboard. The connection was referred from google and make sure these components can be function well. When all the connection is connected correct, we start to do the software which is Arduino language. These coding also referred from online source and we make some adjustment so that it fulfils our criteria for this capstone. Finally, we will troubleshoot on both hardware and software once there is problem being detected.

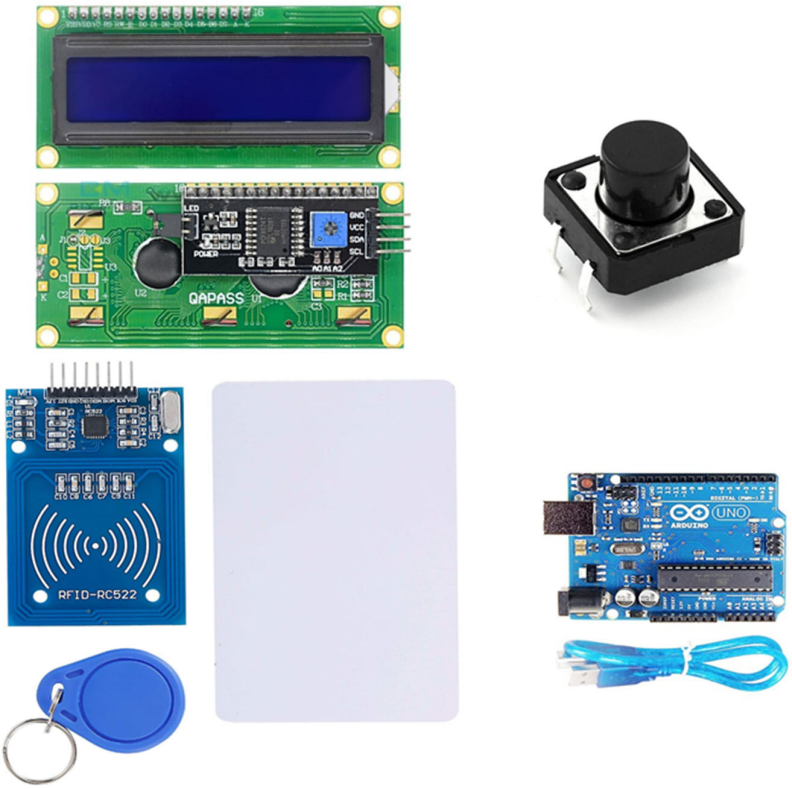


Figure 6: Electronic components in the system

Table 2: The pins connection of electronic components

Arduino Pin Number	RFID Module Connection
Pin 3.3V	3.3 V
Pin 9	RTC RSTSCL
GND	GND
Pin 12	MISO
Pin 11	MOSI
Pin 13	SCK
Pin 10	SDA

Arduino Pin Number	Ic2 crystal led Connection
GND	GND
Pin 5V	VCC
A4	SDA
A5	SCL

Arduino Pin Number	Push Button
Pin 2	Check In
Pin 7	Check Out

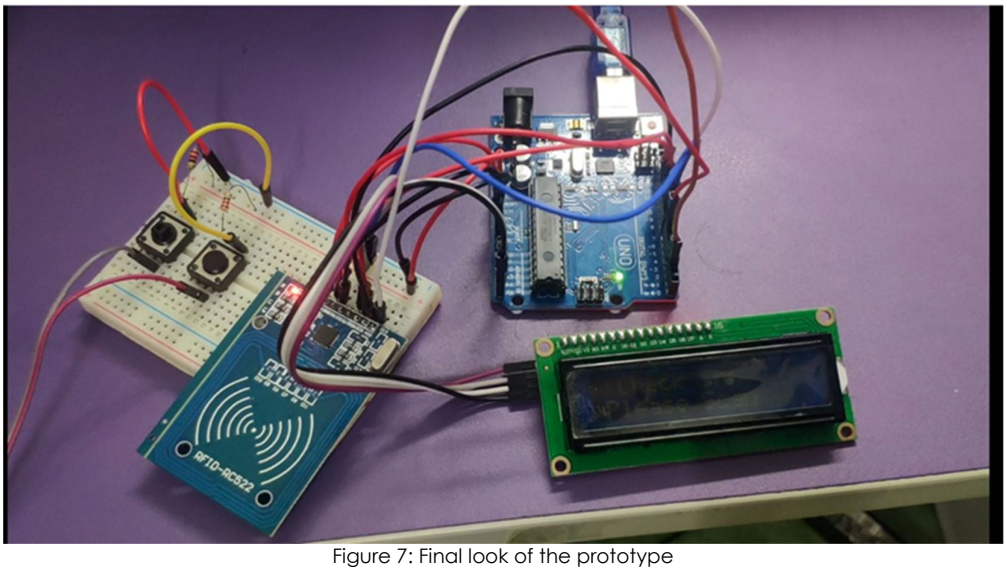
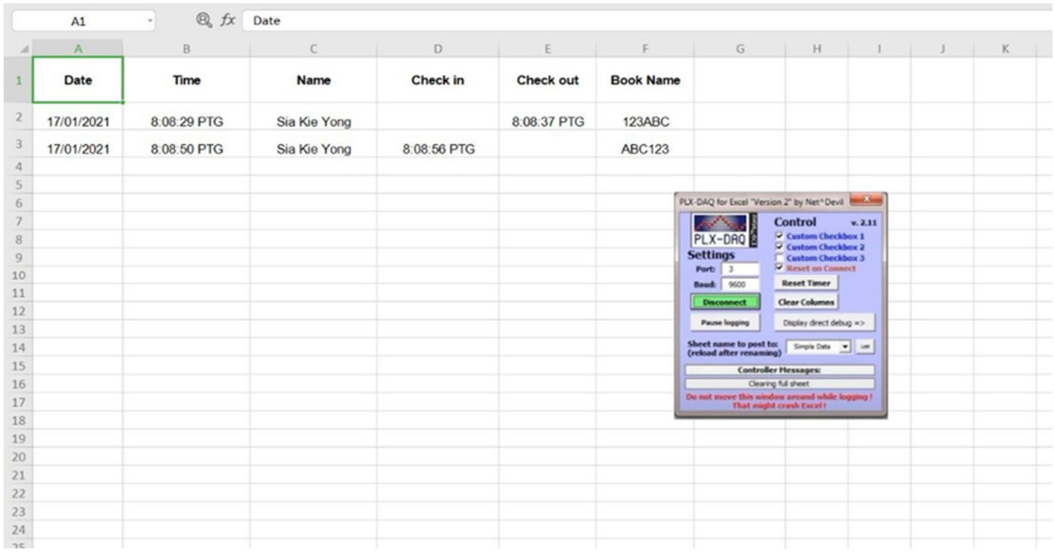


Figure 7: Final look of the prototype



Date	Time	Name	Check in	Check out	Book Name
17/01/2021	8:08:29 PTG	Sia Kie Yong		8:08:37 PTG	123ABC
17/01/2021	8:08:50 PTG	Sia Kie Yong	8:08:56 PTG		ABC123

Figure 8: Smart library management system interface

Operating

This project can operate automatically without the help of a librarian. For borrowing books in the library, students need to choose the book they want to borrow first. After that, he went to the counter to scan the matrix card. If the matrix card is not detected, please try scanning again. RFID reader will read the students information from the matric card. This process is to ensure that only registered people can borrow books at the library. After the student's identity is accepted, the students must scan the book he wants to borrow. RFID reader will read the RFID tag at the book to get the book's information such as the title of the book.

The LCD displays will display the name of the student and the title of the book. So, students can find out whether the titles of the books recorded in the system are the same as those borrowed or not. Next, the information such as the student's name, book title and time will be recorded in Excel file. The similar process for returning the book, students must scan their matric card and book at the FRID reader. Figure 9 shows the flowchart for users to use this system.

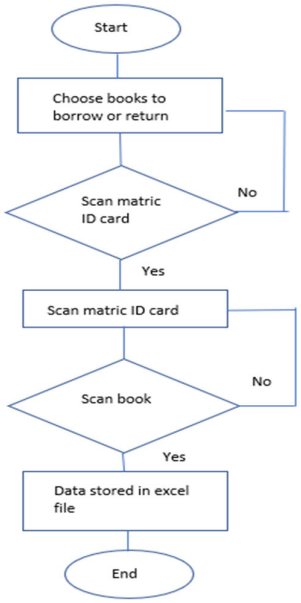


Figure 9: Flow chart of the system

Result and Analysis

The Smart library management system stored the data in an excel file. The system recorded the student name, book title, time and date. The system stored the data successfully. Smart library management system is expected to operate well because the components used have a good quality.

The advantage of this project is students can borrow the book themself without waiting librarian help. Usually, students must wait for the help of librarians to record the book in the system. In addition, this system is also faster than using a barcode system because students only need to scan matric cards and books in the RFID reader. Next, using RFID in libraries saves librarian time by making their tasks with a high degree of automation. Librarians can do other work without worrying about the process of borrowing/returning books.

Innovation

Every school nowadays already got their own library management system. There are some schools that still uses manual check-in and check-out to borrow and return a book. But mostly school nowadays using barcode system. However, this Smart Library Management System uses RFID. RFID systems are much more efficient for scanning as it is faster compared to barcode, and it can read multiple codes at once. Our system also will let the user to borrow or return the book themselves without waiting for the librarian which will save time for both user and librarian compared to barcode system.

The development cost for this prototype might be higher compared to others that use barcode system, but this prototype manages to do the same task of library management system with much more benefits and advantages.

Conclusion

In the conclusion, the project Smart Library Management System is completed and worked successfully. There are several problems faced during the completion of this project. However, all the problems have been solved. There is some improvement that can be done for this Smart Library Management System. For example, to increase the data accessibility from outside the library, the system can send notification to the book borrower when the date is near and improve the system so that it can detect whether the book should be return or borrow when scanned without push the buttons.

Acknowledgement

The project is supported by School of Electrical Engineering, Universiti Teknologi Malaysia.

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[2] K. Dutta (2014), Smart Techniques for School Libraries in the Smart Era, Presidency University, Kolkata.

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Food Order Assistant

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Abstract: The Malaysian Smart School Initiative (MSSI) is the government's holistic approach that involves various stakeholders including the ministry, industry and community to incorporate the use of ICT in schools. Besides implementing ICT in the teaching and learning process, MSSI also emphasizes on the use of ICT in schools' management and administration. In the process of manifesting MSSI, some practices in schools are still conducted manually. These manual practices such as the food order process during recess hinders the smoothness of schools' operation especially during pandemic, as most of the imposed procedures require less contact between humans. The paper proposed an alternative solution to the current practice to improve the process of food ordering system in schools, especially to adhere to the safety measures imposed on schools. The Food Order Assistant is an integrated 3 part system which consists of a Self-order Kiosk, a pre-order website platform and canteen's management system. Through the system, students and teachers have the choice to place orders in real-time through the self-order kiosk system or place a pre-order online via the pre-order website. The system operates fully on cashless payment through RFID technology which provides safe online transactions. The system is also user friendly and easy to use with simple module navigations. Feedback from users proved that the system saves ordering and queueing time, reduces big crowds and complies to the standard operating procedures (SOP) imposed during the pandemic. In addition, the system can help eliminate additional administrative work on teachers especially during the pandemic and at the same time provide a more systematic and advanced way of managing the school towards the efforts of manifesting the smart school vision.

Keywords: food ordering system; food order assistant; self-order food kiosk; smart school canteen

Introduction

Malaysia, like any other countries have been investing heavily on the use of information and communication technology (ICT) in school. The Malaysia Smart School Initiative (MSSI) is a continuous effort initiated by the Ministry of Education (MoE) Malaysia to achieve the minimum standards of technological utilisation, and ensuring the availability and capability of information and communication technology (ICT) application and infrastructures in teaching and learning process as well as the management and administration of schools (Ministry of Education Malaysia, 2013). In the blueprint, the ministry mentioned the 3 waves of implementation which are Wave 1 (2013-2015) to improve the foundation, Wave 2 (2016-2020) to introduce technological innovations, then maintaining the innovations to system-wide usage in Wave 3 (2021-2025). Examples of technologies which are currently implemented to support the manifestation of smart school includes classrooms with multimedia courseware and presentation facilities, computer laboratory for teaching, multimedia development center and server room equipped to handle applications, management databases, and web servers (Siavash Omidinja, *et al*, 2013).

Due to the pandemic, the Ministry of Health (MoH) Malaysia has reminded students and school staff to strictly adhere to the COVID-19 standard operational procedures (SOP) when schools reopen. Among the COVID-19 prevention measures introduced by the ministry is compulsory temperature checks on students, staff and other individuals who have dealings with the schools. Those with temperature above or equal to 37.5°C or those with symptoms are not allowed to enter the school area. In addition, tables in classrooms are to be arranged at least one metre between each other and the maximum capacity in a class is 20 students (Joseph Kaos Jr, 2020). The SOPs with regards to eating in school are also introduced to prevent the spread of COVID-19 virus. Students are encouraged to bring their own meals from home or pre-order packed foods at school to eat in their respective classrooms during recess (Jarud Romadan Khalidi, *et al*, 2020).

Several interviews were conducted to understand the problems and challenges that are faced at schools especially during the pandemic. These interviews were conducted with two (2) primary and secondary school teachers, a secondary school student, a school administrator and a parent. A survey was also conducted through Google Form to explore more responses from these relevant parties and the public and to obtain a more reliable set of data. The survey was distributed to primary and secondary schools' students and teachers. Respondents were asked to share the information which include on how the school manages the SOP during the pandemic, how school manages students' food during their break time and time taken for the students to wait for the food during recess and others.

Findings from the interviews and survey highlighted that, teachers' responsibilities are getting more demanding especially during the pandemic (as in Appendix A). Extra measures are required to ensure that students,

teachers and other school agents follow the required SOPs. Almost all respondents agree that the schools have taken safety measures to ensure that students who enter the school are healthy. Temperature measurements were taken at the school entrance and attendance is recorded prior to class. 25.6 % of respondents mentioned that the queue for temperature check only takes 1 minutes and is manageable using the temperature scanners and some with the QR code system. Most teachers also highlighted that the implementation of online learning requires more preparation and additional monitoring.

Problem statement

During the pandemic, some schools managed recess time by separating the students into forms or class levels and each level had a dedicated time to order food during recess while ensuring physical distancing. Another practice by a school is for teachers to take the order on behalf of the students a week earlier to reduce waiting time during recess. To address the issue, there were several suggestions from the survey respondents which include bringing food from home, making the process of food ordering faster and developing a system or platform to ease the food ordering process.

To ensure that the SOPs are maintained during school hours, teachers in some schools are required to take food orders manually from their students. Parents will order the food for their children through any social media platform (i.e: WhatsApp and Telegram) and the teachers will collect the order before forwarding them to the canteen staff. The teachers need to confirm the orders a day before the actual order date. This is to ensure that the canteen has sufficient time to prepare and pack the foods and students are able to have their meals during recess at school while maintaining the SOPs. Most respondents in the survey responded that students have to wait 10 minutes during food ordering in the midst of the pandemic.

Findings from the survey also show more than 75% of the respondents agree that it is more taxing and challenging on teachers with the demand of additional administrative work during the pandemic. During the interview, a teacher mentioned that it is not a burden but job responsibility whereas school administration mentioned that managing the students' food has been divided equally among the teachers. To address the issues highlighted in the survey and interviews, it is essential to provide support to teachers to help reduce the additional administration work, especially during pandemic. This is to ensure that teachers are able to focus on issues related to students' learning process.

Objectives

The Food Order Assistant is proposed to help minimize the additional administrative tasks that are required especially during pandemic. The system consists of three (3) main parts - the pre-order website, order verification mobile system and self-order kiosk that are integrated to solve the issues of food order.

The food ordering system allows students to order earlier through the pre-order website. The system aims to reduce the time taken for food ordering, as orders can be done beforehand which allows canteen staff to focus on food preparation. Besides the pre-order system, the self-order kiosk is also integrated to the overall system and allows cashless payment by implementing the e-wallet system via RFID cards. This is to speed up the food preparation process and minimize time from cash transactions. Especially during pandemic, the proposed system may reduce the transmission of disease that may happen via cash transactions. The system may also help **r**educe the responsibilities of teachers during pandemic, as food order can be made beforehand. Furthermore, the system encourages food order through self-help options which do not require manual effort from teachers or canteen staff during the ordering process. The proposed solution will not only address the issues during the pandemic but also can be an alternative to improve the food ordering system in schools towards the manifestation of smart schools in the country.

Methodology

The Food Order Assistant system consist of 3 main parts:

- Self-order kiosk system - requires peripheral hardware with RFID reader which consist of the NodeMCU platform and RFID reader for cashless payment
- Pre-order system - requires web browser for food ordering
- Canteen management system - requires a smartphone as hardware for barcode scanning during order verification.

To start an order cycle, the canteen manager is required to initiate the "Open Order" link through the website as illustrated in Figure 1.

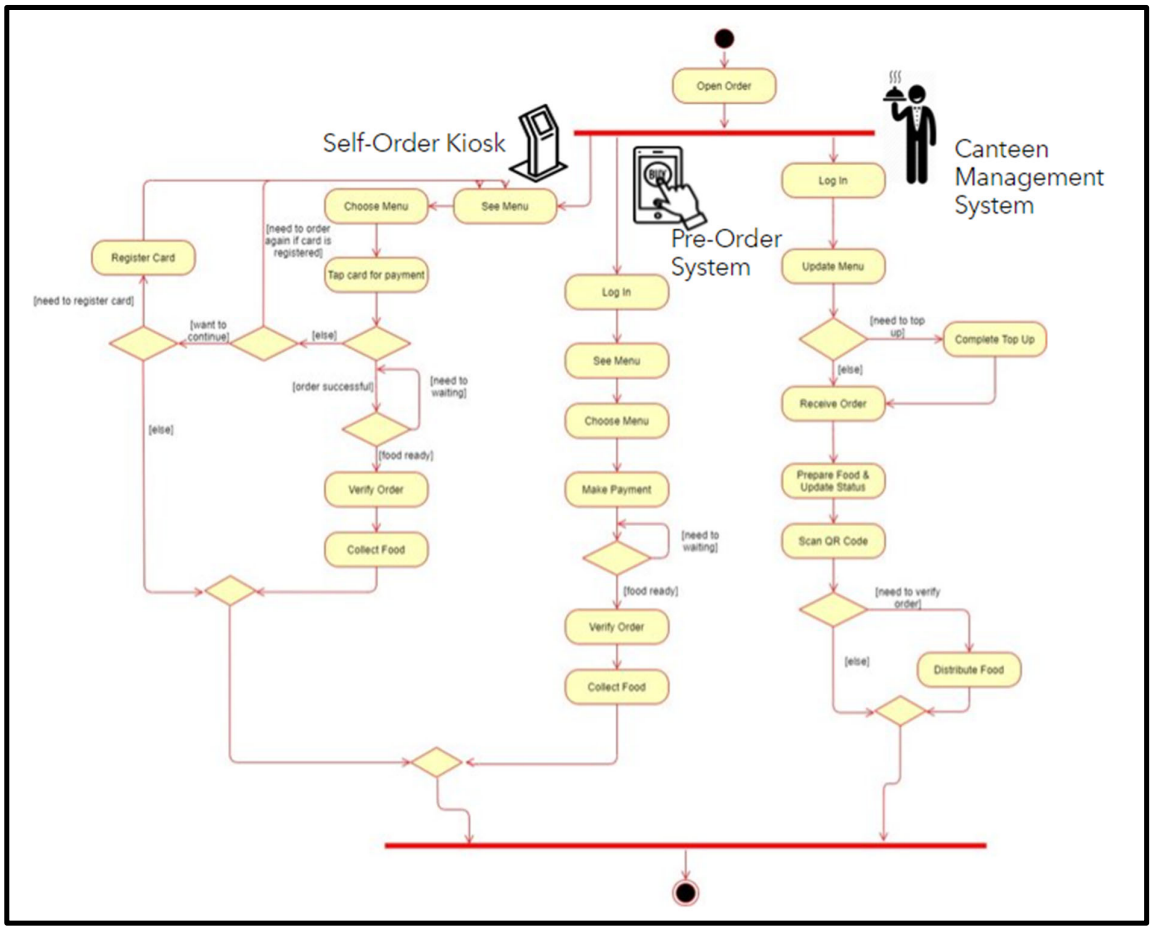


Figure 1: Overall operational flow of the Food Order Assistant system

Self-order Kiosk System

The self-order kiosk system allows users (students, teachers and staff) to order food via a touch screen station placed at the canteen. Food available for the day will be displayed on the system and users can proceed to select the food and drinks to order. Once selection has been made, the user may proceed to checkout. During checkout, the RFID reader machine will be activated and request for payment via the user's registered RFID card. To proceed, the user is required to tap their card to make payment.

Once the card has been tapped on the machine, the display will inform whether the payment is successful. The RFID reader machine will receive a payload response from the server to trigger beep sounds to indicate that payment is successful. A beep sound means that payment is successful, two (2) beep sounds indicates that the payment requires a transaction pin as it exceeds the set payment limit and three (3) beep sounds indicates that the payment is unsuccessful. An unsuccessful payment may be also due to the card that is not linked to a user account. Hence, users may proceed by linking the card to their account over the counter and make payment once the card is linked to their account. The order with successful payment will reach the kitchen's real-time kiosk order display and the kitchen assistant will prepare and deliver the food to the respective user before serving the next customer.

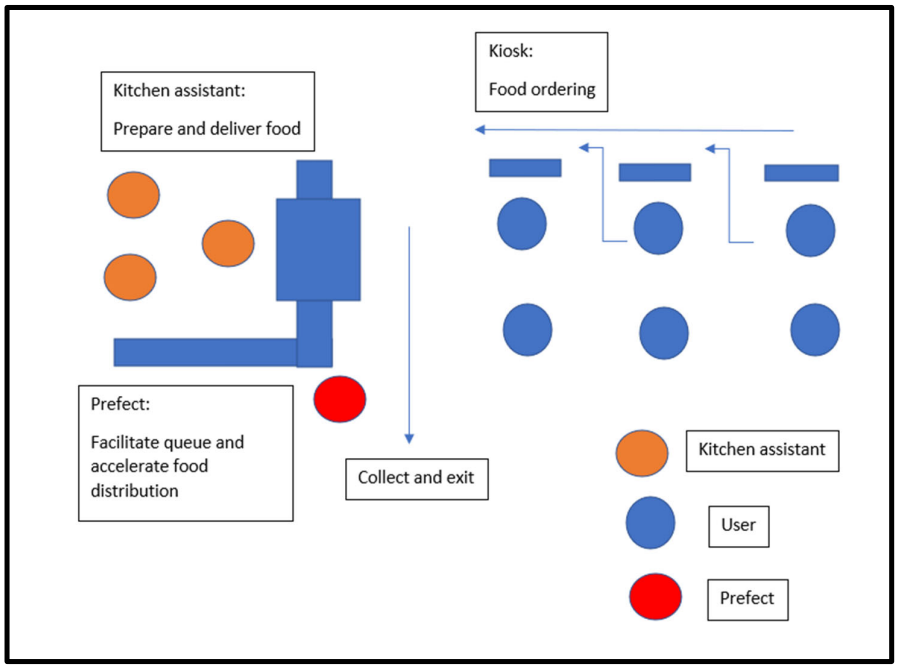


Figure 2: Graphical flow for food order via self-order kiosk at the canteen

Figure 2 shows the suggested flow for food order via the self-order kiosk system at the canteen during recess and non-recess time. The canteen operator may choose to have a kitchen assistant serving multiple kiosks at a time to accelerate the food ordering time. Upon completion of food ordering, schools may assign prefects or student monitors at the canteen to facilitate queuing during recess time. They may also help the canteen to pause the kiosk food ordering if the number of users who have not received food order exceeds the threshold limit. Alternative to that, a kitchen assistant may be required to facilitate the queue and food distribution process.

Pre-order System

The pre-order system allows users to place their food order earlier as shown in Figure 1. Users may login to their single-sign-on user account which consists of the pre-order system's link, user profile management, credit wallet management and update password on the system. Parents may facilitate the process for lower primary students.
To place a pre-order, users are required to proceed to the "Pre-order" tab that links to the pre-order system. The available food for the day will be displayed in the system and users can select food and proceed to checkout once food selection has been made. During checkout if the user's balance is sufficient, they may proceed to checkout with success order. However, if the amount exceeds the payment limit, the system will prompt the user to key in the transaction pin as a second authentication. If the user's balance is insufficient, the user will not be able to checkout. Upon a successful checkout, the canteen's kitchen will receive the order and prepare the order accordingly. Depending on the canteen's preference, they may choose to deliver the food to class, set an estimated food delivery time for each class or to prepare the food for bulk collection by class representatives.

Canteen Management System

There are 2 subflows related to the canteen management system:

- Manual account top-up
- Verify pre-order food

For users with insufficient balance, they may proceed to top-up their account, either over the counter or bank transfer for manual top-up before performing pre-ordering.

Verification is required upon food collection by class representatives or food delivery by canteen staff. As depicted in Figure 3, the first scanning is conducted on the class order barcode to verify the existence of the order in the system. The second barcode scanning scans on the user barcode or QR code to ensure that the user's order is listed in the ordering list. For bulk food collection, any one of the users from the class who has placed a food pre-order can be the representative and is required to be present for order verification.

A mobile application was designed to verify pre-orders made through the website. The application was developed to ensure that the right food order is delivered during collection. The application will be used by the canteen staff to verify the order by scanning the QR code or barcode provided on the printed receipt. Figure 3 shows the flow of the order verification process via mobile application.

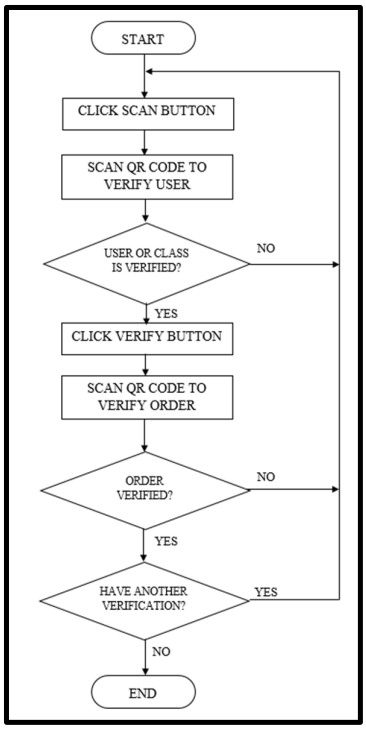


Figure 3 : Flow of food order verification via mobile application

Product development

System's Frontend

The system's frontend or user interface was developed through web-based programming and utilized bootstrap framework to enhance the user interface (UI) and provide a user friendly system. Programming and scripting involved are preprocessor hypertext programming (PHP), Structured Query Language (SQL) and javascript.

Self-order Kiosk System

The Food Order Assistant is integrated with the Self-order Kiosk which is suggested to be located at the canteen. The self-order kiosk allows cashless payment during real time food ordering via an RFID reader. It is able to extract data from the RFID card which usually consists of ten (10) digit unique numbers that will be sent to the web server to perform payment. An example of an RFID card is the Touch n' Go card which allows users to add a certain amount to it and functions as an e-wallet. A buzzer will beep upon the detection of the RFID card by the RC 522 RFID reader to avoid double scanning that might lead to other issues such as double payment. The frequency of beep sounds indicate different conditions. A beep determines successful events such as "successful payment" and "successful card update", 2 beeps indicates that "payment require transaction pin" for accounts that has initially set money limit and 3 beeps indicates failed events such as "card number already exist", "update card error", "error" and "payment failed". Payment processes are conducted through the NodeMCU platform which will send the data to the web server. The circuit connection between the hardware for the RFID module is illustrated in Figure 4.

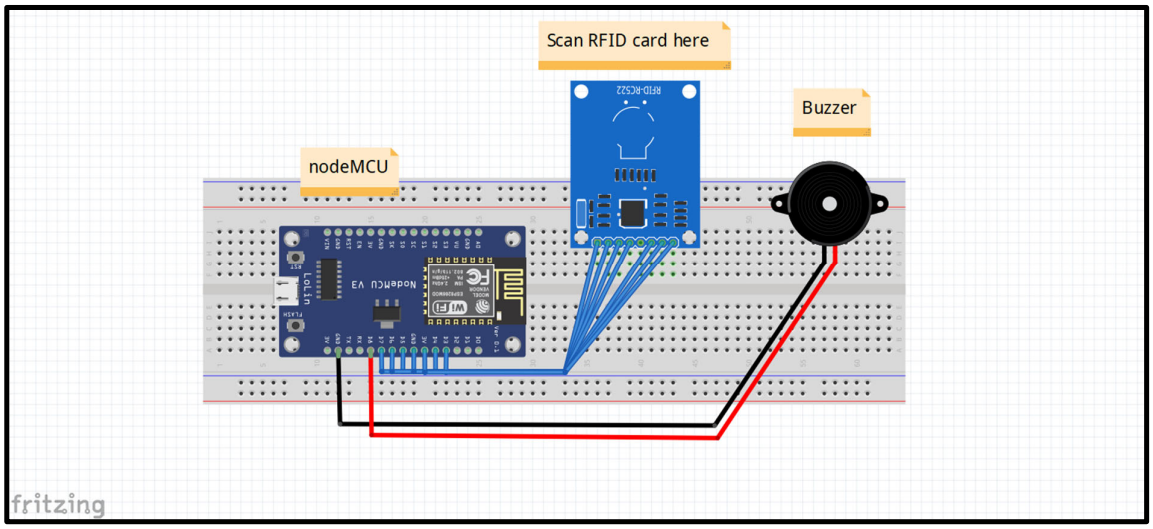


Figure 4: RFID scanner circuit.

The first coding part of the RFID scanner (refer to Appendix D) was written to test the process of sending data through NodeMCU to a database in the web server. The system started by connecting to a WiFi or mobile hotspot, using VPN to connect to a web server and finally sending any random digits to the web server.

rfid2	1175772430	Fri, 18 Dec 2020 at 10:48:02 pm	Remove
rfid2	1308404228	Fri, 18 Dec 2020 at 10:49:21 pm	Remove
rfid2	1168951037	Sat, 19 Dec 2020 at 12:01:55 am	Remove
rfid2	1951833264	Sat, 19 Dec 2020 at 10:33:33 pm	Remove
rfid2	1951833264	Sat, 19 Dec 2020 at 10:40:33 pm	Remove
rfid2	2369315433	Sat, 19 Dec 2020 at 10:52:56 pm	Remove

Figure 5: Successful code testing which shows detection of RFID scanner name (rfid2) and unique 10 digit number with corresponding date and time.

Figure 5 shows the successful code testing which was able to detect the name of the RFID scanner (rfid2) and display random digits with complete time and date stamps. The purpose of the test was to evaluate if NodeMCU managed to send the data to be used in the web server. Figure 6 shows the example of the scanned RFID cards used (normal RFID card and matric card) with the corresponding 10 digits unique number.

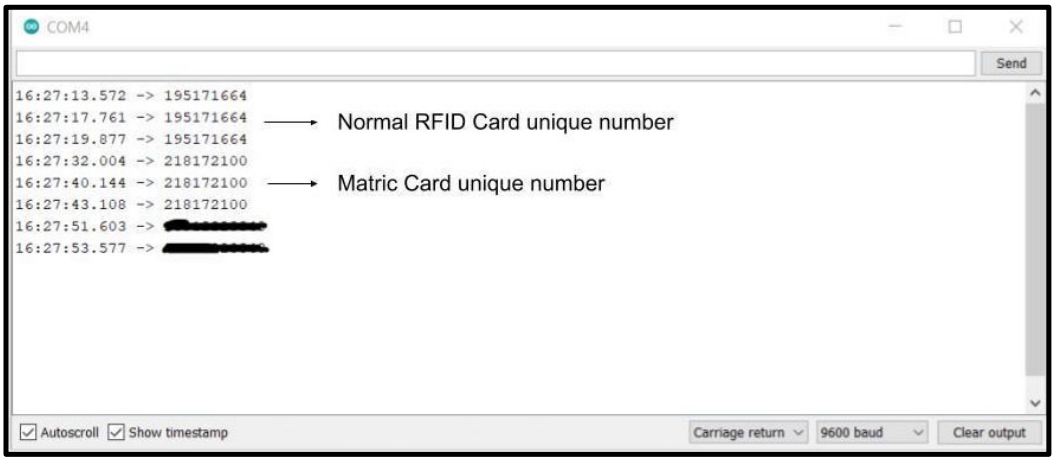


Figure 6 : Successful detection of different RFID cards with their corresponding 10 digit unique numbers.

Pre-order System

The pre-order system allows users to purchase foods beforehand and collect the food during recess time. Figure 7 shows the flow for the pre-order system.

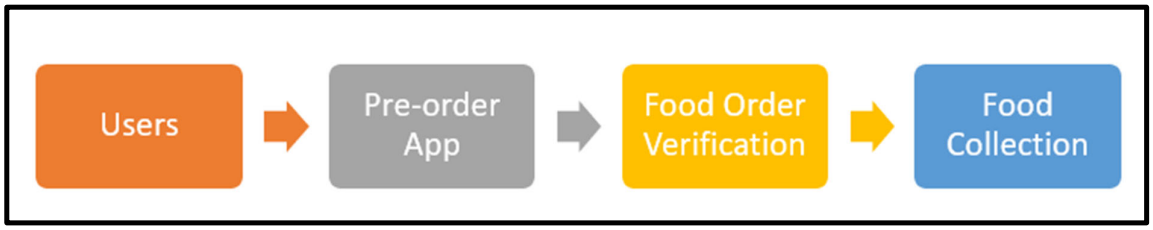


Figure 7: Pre-order system's flow

To select food, users need to access the pre-order web-based application. After selecting food, they may proceed to checkout. Upon the completion of pre-order on the user's side, the food order will appear at the canteen's end for food preparation and delivery. During food collection, users are required to present the generated barcode or QR code for food order verification. Once food verification is successful, users will be able to collect their food order.

There are several modules that were designed in the pre-order web-based application to be used from the user's end and also from the canteen's end. In the User's Profile Management module (as shown, users may update their details such as, class, email address, parent's name and parent's email address. Users can also download their user's barcode from this module to be used during food order verification.

User Account Management

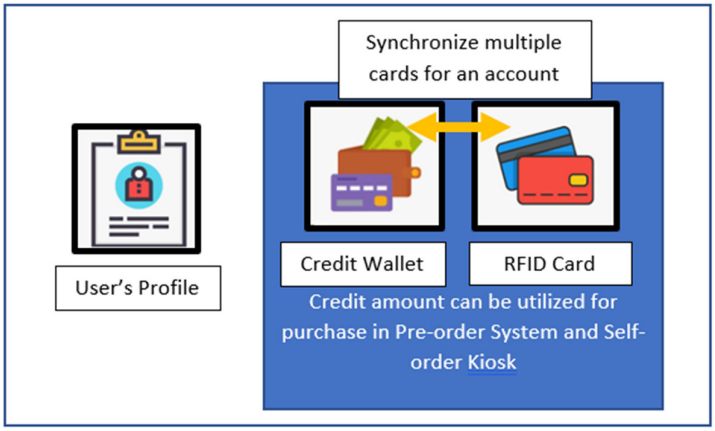


Figure 8: Modules for User Account Management

Users are able to manage their credit amount via the Credit Wallet module which allows users to change the limit for credit wallet payment in the pre-order system and also real-time FPX reload from third-party financing application, Billplz. For security purposes, the Card Management module was designed to allow users to set a threshold amount per transaction to prevent large amounts of loss due to unauthorized transactions. Users can deactivate lost cards at the user-end at any time.

Canteen Management System

In the canteen's management system as shown in Figure 9, the User Management module allows the Admin to register and change the details of any users manually. It also allows the Admin to register multiple users at the same time. Once an account is registered, the Admin is able to synchronize the user's account to a dedicated RFID card via the RFID Card Management module. Multiple RFID cards can be synchronized with a user account. The canteen can also deactivate, re-activate and remove RFID cards from the system via this module. All credit transactions can be accessed by the canteen Admin through the Credit Management module. This module also allows the Admin to control the credit of each user manually.

To set up a pre-order cycle, the canteen staff is required to insert and update the food menu for both kiosk or pre-order systems through the Pre-Order Management module. It allows the canteen to track and update food order status. All paid pre-orders will be sent to the kitchen to be prepared. Once ready, the canteen staff uses the Pre-

Order Verification module to verify food order through barcode or QR code scanning. Food verification is required to ensure that the correct order is delivered to the users.

Users have the option to place orders in real-time through the self-order kiosk. The canteen Admin sets up the kiosk system via the Kiosk Management module and is able to specify the food menu and the time for the kiosk system to accept food orders. The Kiosk Order Display module displays the order from the kiosk system in real-time. Once orders from the kiosk system appear on the display, the canteen staff will consolidate the food and deliver to the corresponding user. All maintenance and administrative activities are conducted via the System Maintenance module which also allows the canteen to backup the system's database to prevent loss of data.

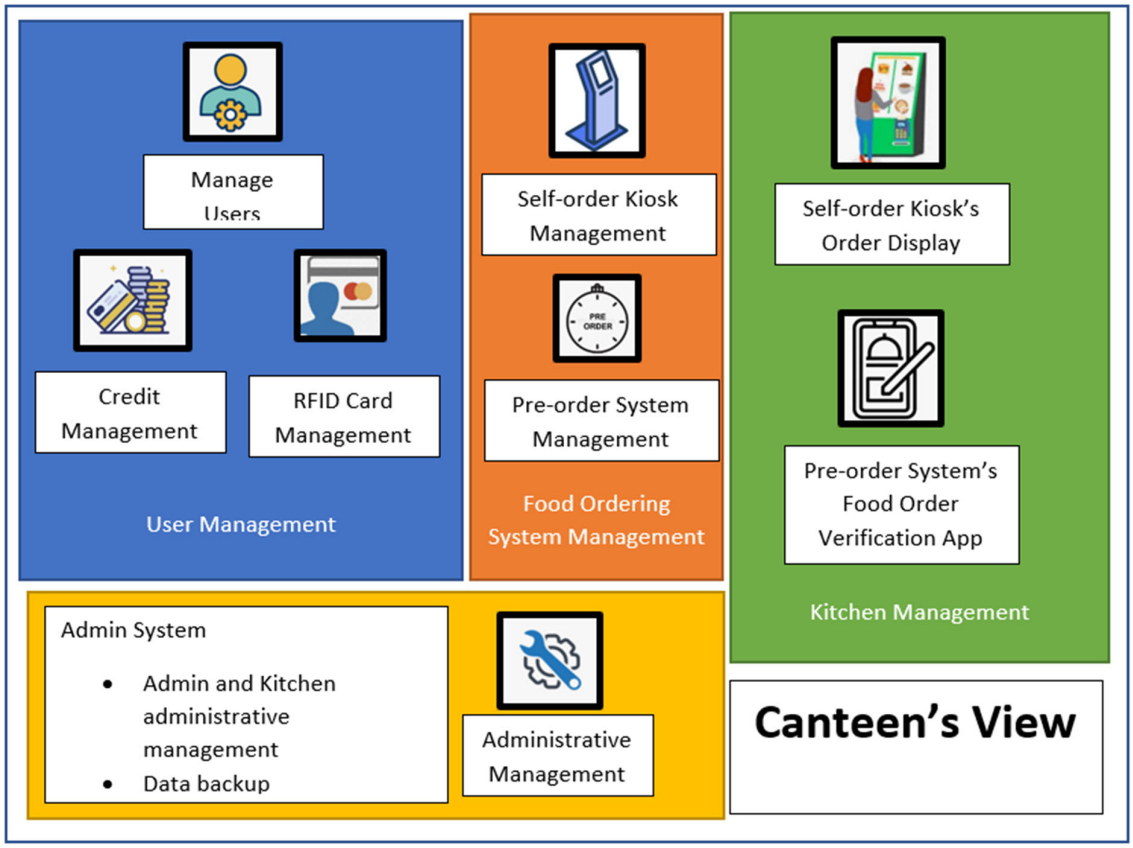


Figure 9: Modules for Canteen Management System

System's Backend

Server

A personal laptop which is an available resource has been utilized to act as the server for the product development in this project. To enable the environment of the server, two packages have been installed:

- Apache - well known for running servers and an open-source package. It is suitable to run various programming languages such as perl, Java and preprocessor hypertext programming (PHP) for web development.
- MySQL Database - Structured Query Language (SQL) is well known for structured data storage and allows efficient querying of data.

Network

The system is hosted in the local area network (LAN) as from observation, most schools have limited access to the internet. The router acts as an access point for the LAN and assigned the Internet Protocol (IP) address for the local machine that hosts the system and also the peripheral device or hardware NodeMCU. Figure 10 displays the detected IP address for the device as below:

Router IPv4: 192.168.0.197

Server Machine IPv4: 192.168.0.195 (assigned by router)

```
Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . :
   Link-local IPv6 Address . . . . . : fe80::7cf9:b787:601f:5ab%13
   IPv4 Address. . . . . . . . . . . : 192.168.0.195
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.0.197
```

Figure 10: Local Area Network (LAN) IP address for router and machine

Results & Discussion

System's Frontend

Self-order Kiosk via RFID

Figure 11 models the self-order kiosk that consists of a touch screen monitor for a real time food order and RFID scanner to allow cashless payment through any registered RFID cards. The system eliminates cash payment that leads to many benefits such as ensuring finance safety, encourages a cashless system and also helps sustain nature by minimizing the use of paper. RFID systems are widely used in fast food restaurants and other shops, which only requires users to tap a card for payment confirmation. It allows less contact between users and is highly encouraged especially during the pandemic. NodeMCU is used as it is a low-cost open source IoT platform and is also a common microcontroller which uses Arduino IDE for coding, that has many references.

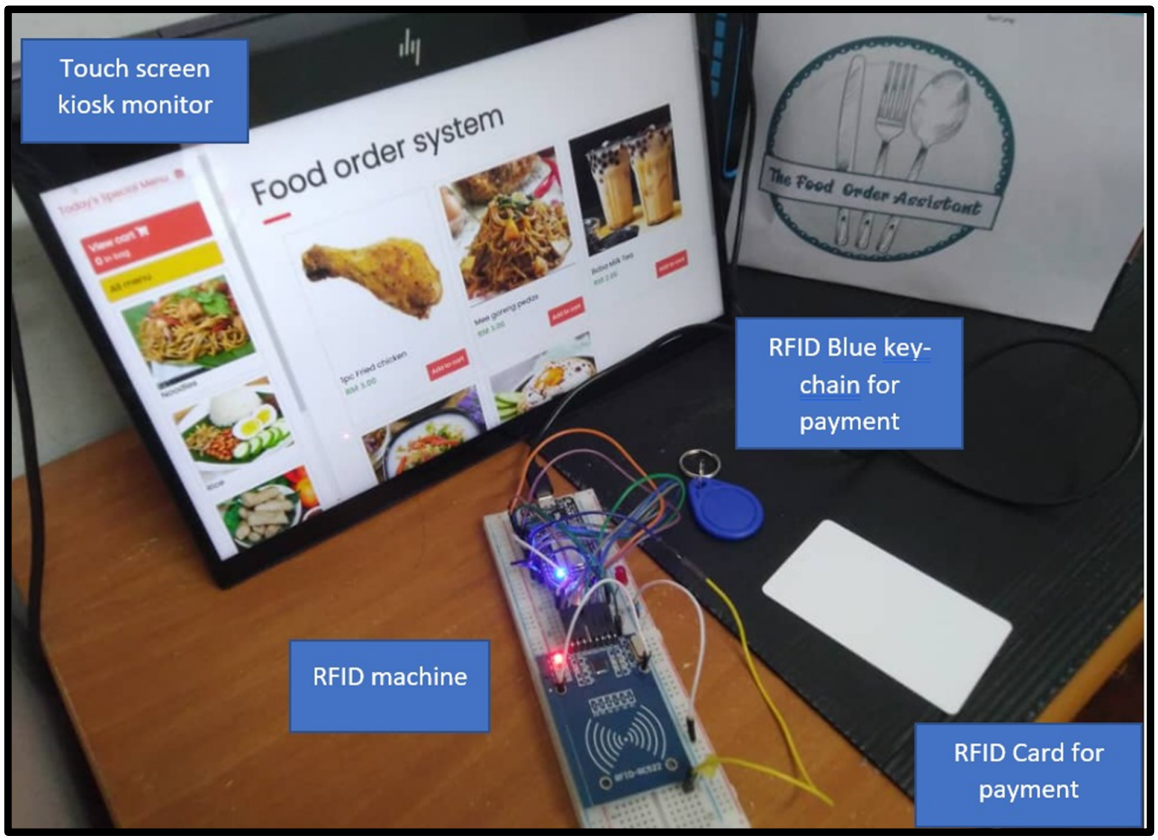


Figure 11: Model of the Self-order Kiosk with the RFID scanner.

The programming language used in this project is PHP, SQL and javascript due to most external remote shared servers such as Exabytes.com, RockSoft.net and etc offer the Apache environment that supports the programming language. Hence, if the local area server fails to work during prototype development, an external remote server will be available for quick backup on the project since many options are available. However, during prototype development, there was no encounter of such situation. Hence, it can be assumed that the server is able to run without any problem in the LAN and the NodeMCU hardware is able to communicate with servers within the LAN. Based on the preliminary results, it provides motivation that the system is able to run with limited or no internet access which is the key problem in most of the schools.

User's Module System Interface

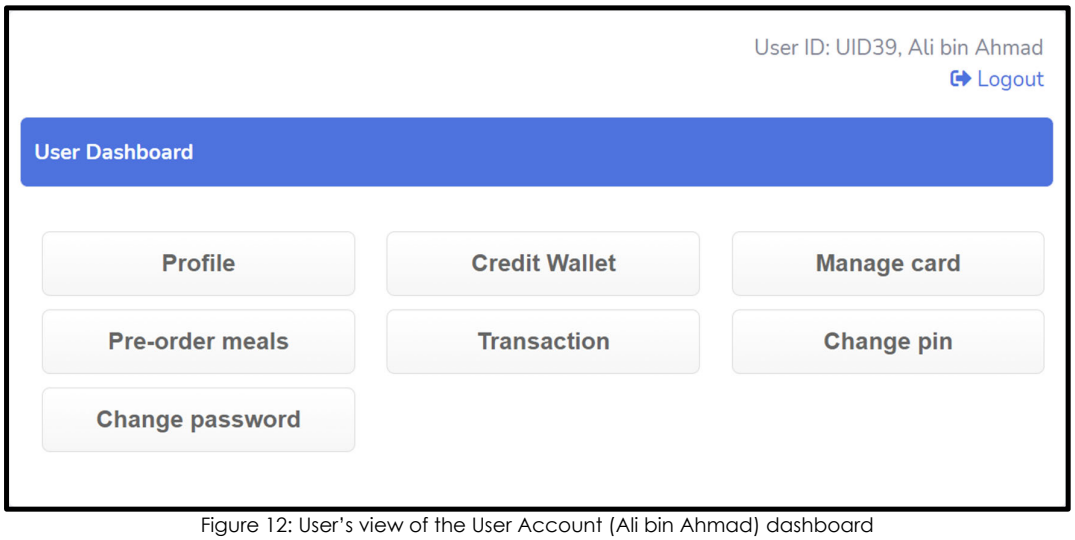


Figure 12: User's view of the User Account (Ali bin Ahmad) dashboard

Figure 12 is an example of the frontend user account named Ali bin Ahmad. In the Profile module as shown in Figure 13, users are allowed to view their information and the barcode or QR code to be used during food collection. In the Credit Wallet section (as shown in Figure 14), users are able to view their e-wallet balance and the transactions records which help parents to have an eye on student's expenses at school. Besides, users can also top-up their e-wallet amount through the Credit Wallet section to ensure sufficient balance during each transaction. Students who lost their registered RFID card can deactivate the card immediately to prevent others from using it through the Manage Card section. A new card can be added to link to the user's account or reactivation of the previous card is allowed if the card is found.

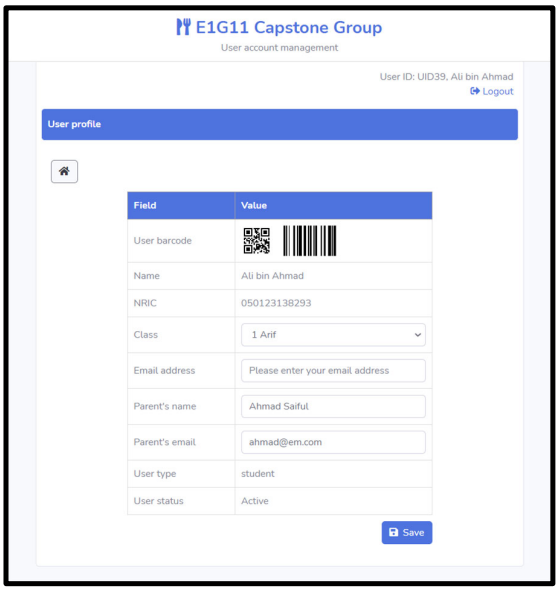


Figure 13: User's view of the User Profile module

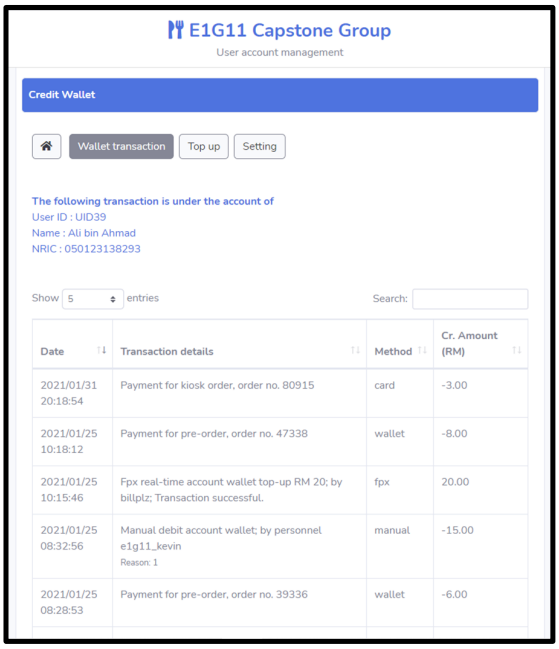


Figure 14: User's view of Credit Wallet module

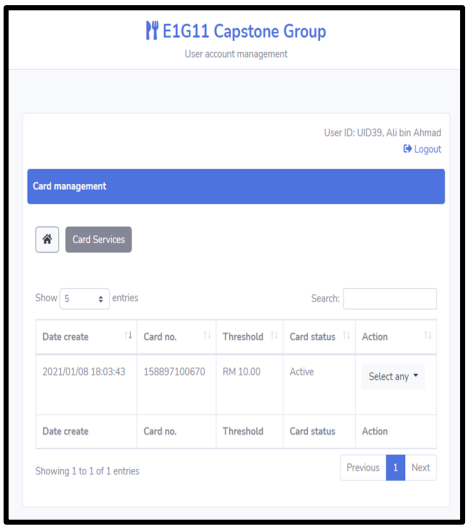


Figure 15: User's view of Card Management module

In the Pre-order meals section, students or teachers can place their order prior to the day of collection. The module will only be accessible when the canteen Admin activates the pre-order system from the canteen's module to accept orders from users (refer to Figure 16) (a) and (b)). Transaction details and receipt can be retrieved via the Transaction module as in Figure 17.

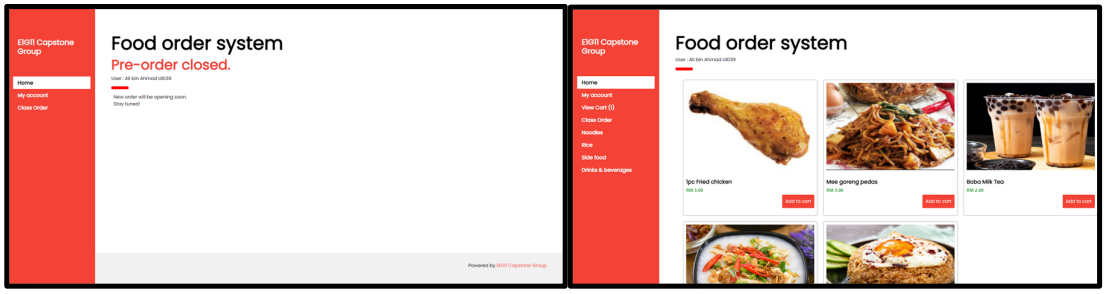


Figure 16: Food Order System (a) closed and (b) open for pre-order

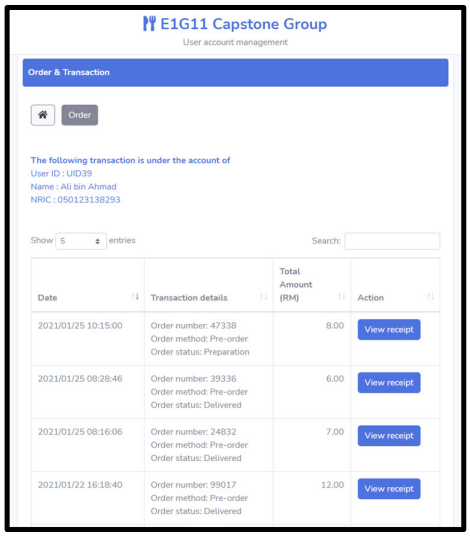


Figure 17: User's view of transaction order records

For safety purposes, the Change Transaction Pin module in Figure 18 was designed to control every transaction and to ensure that it is within the transaction limits. The transaction pin will be needed when the amount purchased exceeds the set limit. The pin can be set or changed via this link. A six (6) digits number is required for setting up the pin.

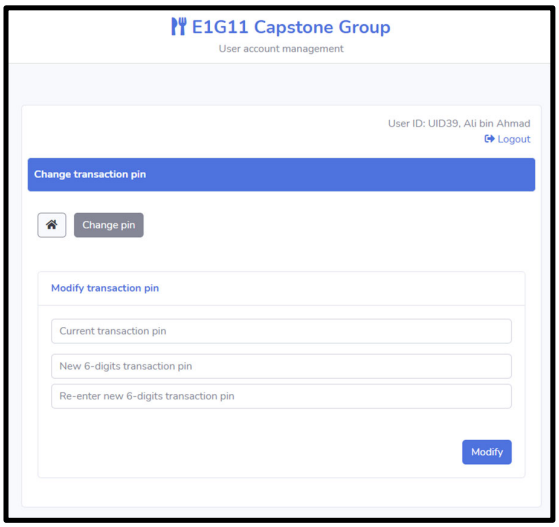


Figure 18: User's view to modify pin transaction in the Change Transaction Pin module

Password is required to login the user account and can be changed to increase the security of the account through the Change Password section as in Figure 19.

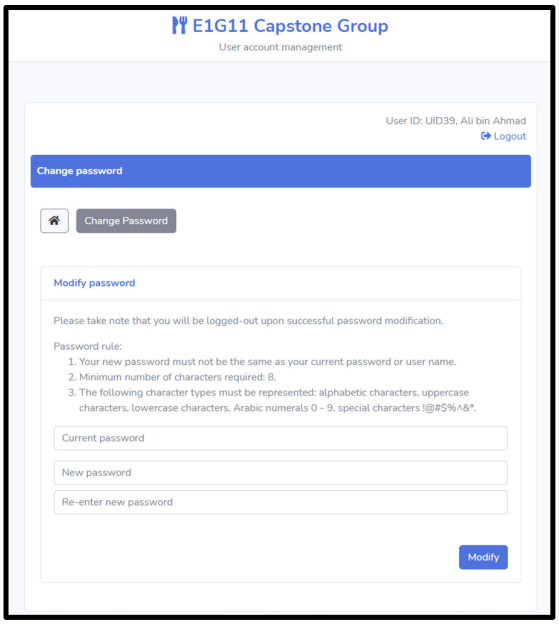


Figure 19: User's view to modify password in the Change Password section

Canteen's Module Interface

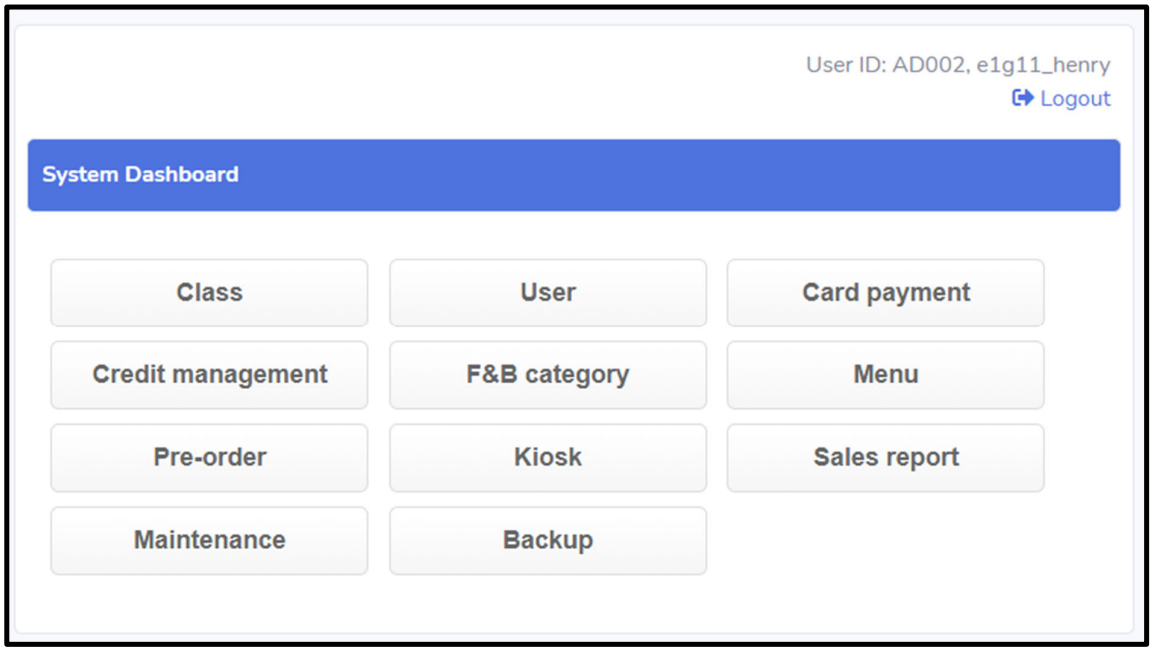


Figure 20: Admin's account (Henry) view of the Canteen's Module Dashboard

An example of the backend user account which is the canteen administrator named e1g11_henry is displayed in Figure 20. In this account, canteen staff or owners can view, remove and add in the classes from the school list via the Class module in Figure 21. This feature can help canteen staff to track orders and group them together once all orders are ready.

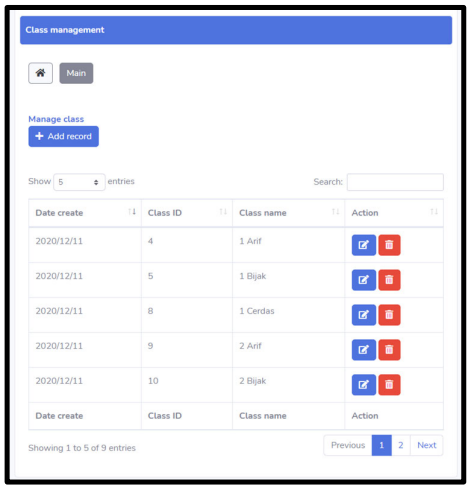


Figure 21: Admin's view for class management in Class module

Beside viewing the class order, they can also view, remove or add in new users to the system through the User section as in Figure 22. All registered user accounts will be shown in this section and Admin is allowed to make amendments to the account if required.

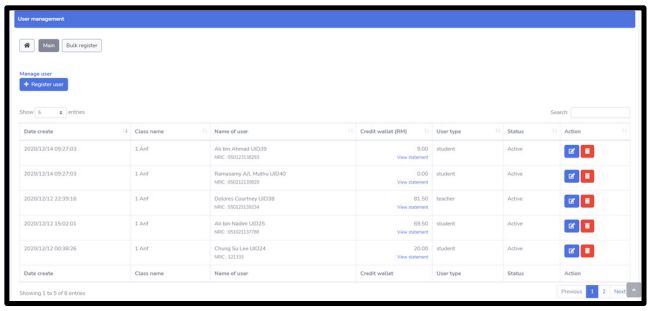


Figure 22: Admin's view for individual user management

Admin can also manage the linked registered card for every user, add cards for a new user and deactivate cards for users who lost their card through this module as shown in Figure 23. Besides adding and removing cards, the credit amount of each linked card can be done by the canteen Admin via the Credit Management section in Figure 24. Students who are not able to top up or add credit by themselve can request the action to be done at the school canteen to have sufficient balance for food ordering.

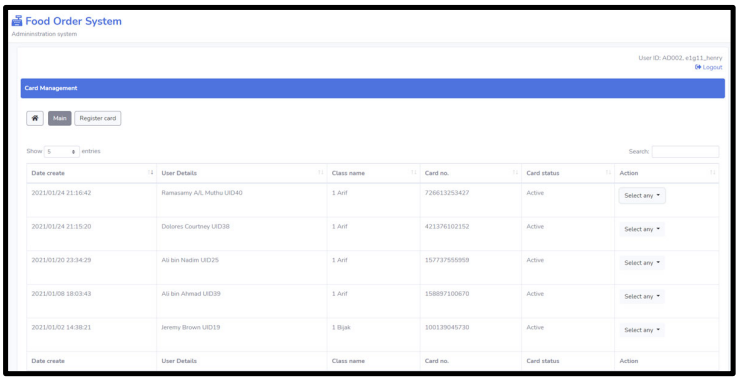


Figure 23: Admin's view of Card Management module(admin view)

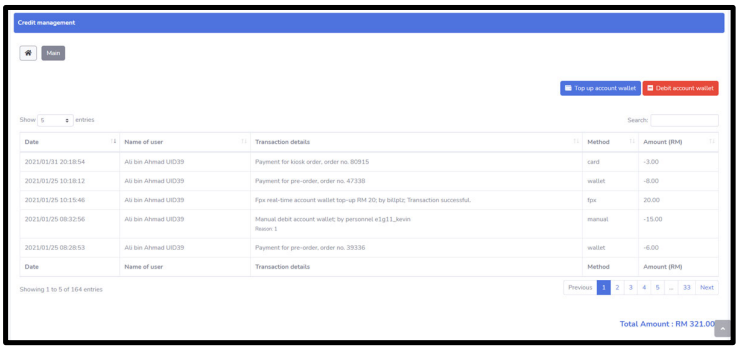


Figure 24: Admin's view of Credit Management module

Upon the setting up of available food , foods are grouped into different categories and the menu can be created at the Menu section. The created menu will then be added to the Pre-order section (as in Figure 25) and the self-order Kiosk Management system (as in Figure 26). The Pre-order and Kiosk system are simultaneously open or close by setting up the pre-order or turning it off. Users will be able to order once the pre-order is already set up by the canteen Admin and ready to accept orders from users.

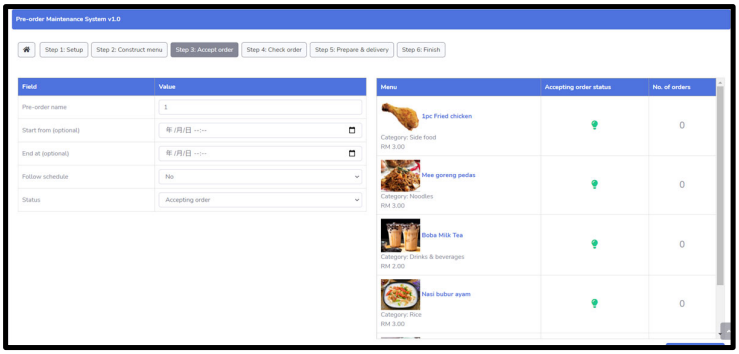


Figure 25: Admin's view of available food for order in the Pre-order Management System

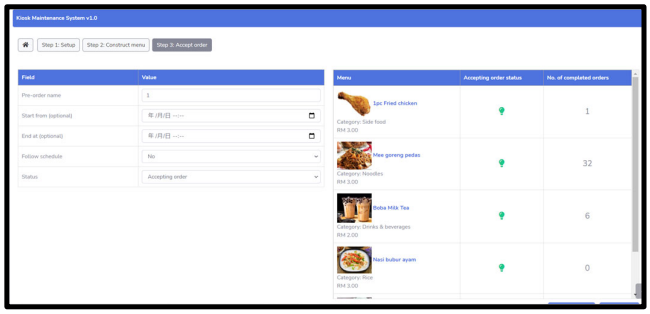
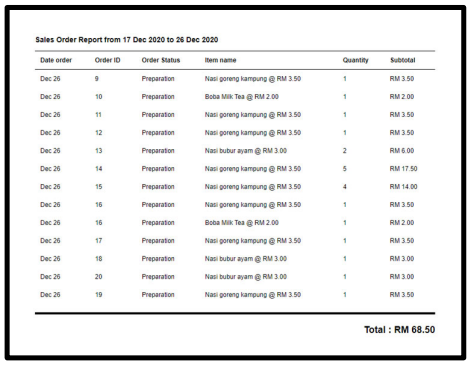


Figure 26: Admin's view of available food menu in the Kiosk Management System

The system is also equipped with the Sales Report module which allows canteen Admin to generate sales reports between two interval dates. The sales report will only print out successful orders and completed orders which involved successful money transactions. The total amount of every order and the total amount of all the sales between the selected time interval dates will be calculated and displayed automatically as shown in Figure 27.



Sales Order Report from 17 Dec 2020 to 26 Dec 2020

Date order	Order ID	Order Status	Item name	Quantity	Subtotal
Dec 26	9	Preparation	Nasi goreng kampung @ RM 3.50	1	RM 3.50
Dec 26	10	Preparation	Boba Milk Tea @ RM 2.00	1	RM 2.00
Dec 26	11	Preparation	Nasi goreng kampung @ RM 3.50	1	RM 3.50
Dec 26	12	Preparation	Nasi goreng kampung @ RM 3.50	1	RM 3.50
Dec 26	13	Preparation	Nasi bubur ayam @ RM 3.00	2	RM 6.00
Dec 26	14	Preparation	Nasi goreng kampung @ RM 3.50	5	RM 17.50
Dec 26	15	Preparation	Nasi goreng kampung @ RM 3.50	4	RM 14.00
Dec 26	16	Preparation	Nasi goreng kampung @ RM 3.50	1	RM 3.50
Dec 26	16	Preparation	Boba Milk Tea @ RM 2.00	1	RM 2.00
Dec 26	17	Preparation	Nasi goreng kampung @ RM 3.50	1	RM 3.50
Dec 26	18	Preparation	Nasi bubur ayam @ RM 3.00	1	RM 3.00
Dec 26	20	Preparation	Nasi bubur ayam @ RM 3.00	1	RM 3.00
Dec 26	19	Preparation	Nasi goreng kampung @ RM 3.50	1	RM 3.50

Total : RM 68.50

Figure 27: Example of a sales report from 17 Dec - 26 Dec 2020

For maintenance purposes, the Maintenance module in Figure 28 was designed to ensure the system can operate well and is consistently active for the users and admin.

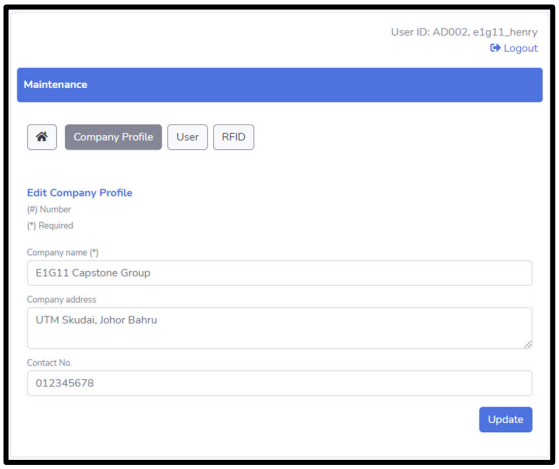


Figure 28: Maintenance for Admin, RFID and user system

The Backup section as in Figure 29 can help Admin to backup sales data, users' data, card management in the database in the form of SQL format to prevent data loss.

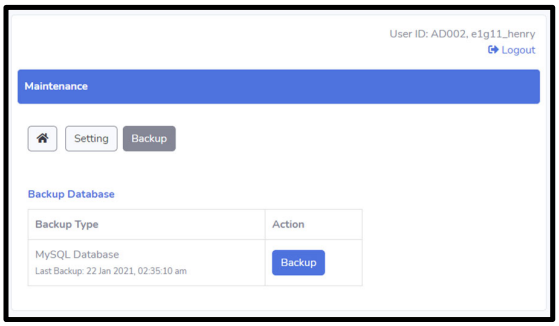


Figure 29: Backup of data to database to prevent data loss.

Food Order Verification System

The Food Order Verification system was designed to be used by canteen staff during food collection or food delivery. Upon starting the application, the user will see a landing page of the Food Order Assistant as shown Figure 30.

Figure 30: Landing page of the Food Order Assistant mobile application

Upon loading, the system will check for internet connection availability. The screen display will show ' Loading' as in Figure 31 if the internet connection is available and will display an error message as in Figure 32 if internet connection is not available.

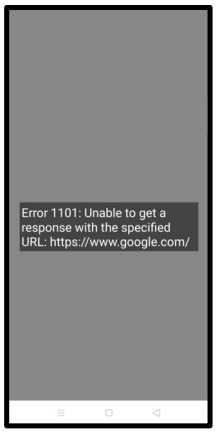


Figure 31: Screen display for 'Online' status

Figure 32: Error message for 'Offline' status

Once the loading process is completed, the user will be prompted to scan via the 'SCAN' button as shown in Figure 33. The canteen staff needs to click on the SCAN button, and scan either the QR code or barcode on the receipt for user or class verification. If a user or class exists, the application will display a user or class verification screen as in Figure 34.

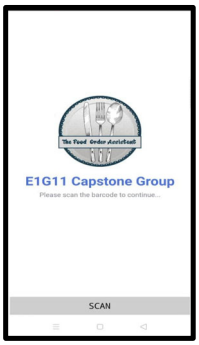


Figure 33: Screen display to prompt 'SCAN'

Once verified, the canteen staff will need to click on the VERIFY button to load the order details. This is to ensure that the student collecting the food has pre-ordered earlier, or is collecting the pre-order on behalf of the class. If the pre-orders are available in the system, the list of orders ready to be collected will be displayed upon scanning the QR/Barcode for the second time. Upon collection, the canteen staff is required to verify that the order is completed by clicking the Verify Order Complete button as shown in Figure 35 and lastly, COMPLETE button as shown in Figure 36.

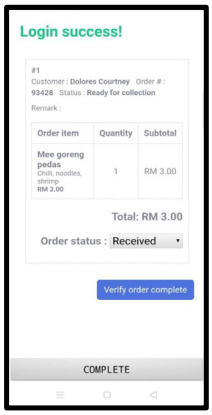


Figure 34: Successful verification of User or Class

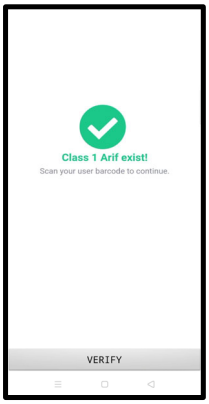


Figure 35: Screen display for 'Ready for Collection' orders

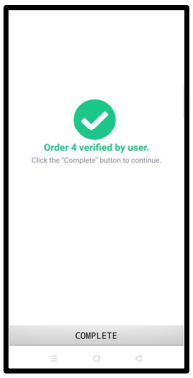


Figure 36: Complete Order screen display

System's Backend

Server

The server machine is the core of the system that hosts the system. Data sensing by the RFID reader is first processed by NodeMCU when a user taps their card. Then, NodeMCU sends the data to the server machine for processing. The server machine processes and stores the processed data. It also sends feedback to the peripheral device, such as the beep sounds produced after the payment to indicate the status of payment.
For lower cost implementation, the Raspberry Pi 4 Model B with 4 GB RAM variant can be used to substitute the hardware used in this prototype development (refer to Table B.1 in Appendix B). It can also host the system dedicatedly according to Hughes (2020) on hosting a web server. In the documentation on setting up a routed wireless access point by Hughes (2020), it is mentioned that Raspberry Pi 4 can also act as an access point to establish a wireless local area network.

Network

For transmission of data using WiFi, there are two types of frequency band which are 2.4 GHz and 5 GHz. Table 2 in Appendix B compares the trade-offs between both frequency bands. Even though 5 GHz offers high speed benefits, NodeMCU is only able to receive data transmission for 2.4 GHz, and does not support the use of 5 GHz.

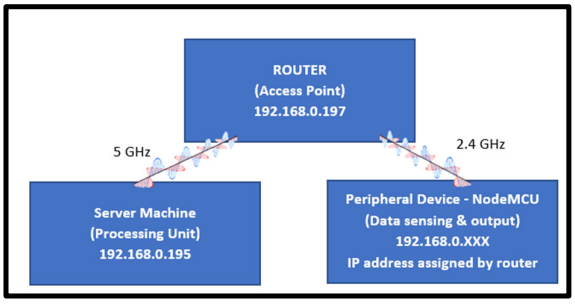


Figure 37: Network Configuration Between Hardwares

Hence, 2.4 GHz was used for the data transmission from router to NodeMCU, but 5 GHz for the data transmission from the router to the local machine. This is due to the position which is usually static and it can be placed nearest possible to the router. Therefore, it does not require wide range transmission and can utilize the fast data transmission if the main unit supports the use of 5 GHz frequency. The main unit can even utilize wired LAN connection to increase the stability of connection. However, the peripheral's position is usually not static and subject to change based on its position suitability. Hence, longer range transmission allows this flexibility, and if needed, a WiFi booster can be used to increase the data transmission range. Figure 37 shows the network configuration between the router, server machine and peripheral devices.

Reviews from Users

Upon completion of the system design, the Food Order Assistant system was tested by several users - four (4) teachers and a canteen operator. Prior to the system trial, a brief explanation and demonstration was conducted. The system was tested on their own devices and all the features worked well. During the system testing, the users also asked some questions to understand more about the system and related conditions at school. Positive feedback were obtained from the users as shown in Figure 38, which reflects that the system is suitable to be implemented in schools and will help reduce the additional work for teachers and also canteen staff.

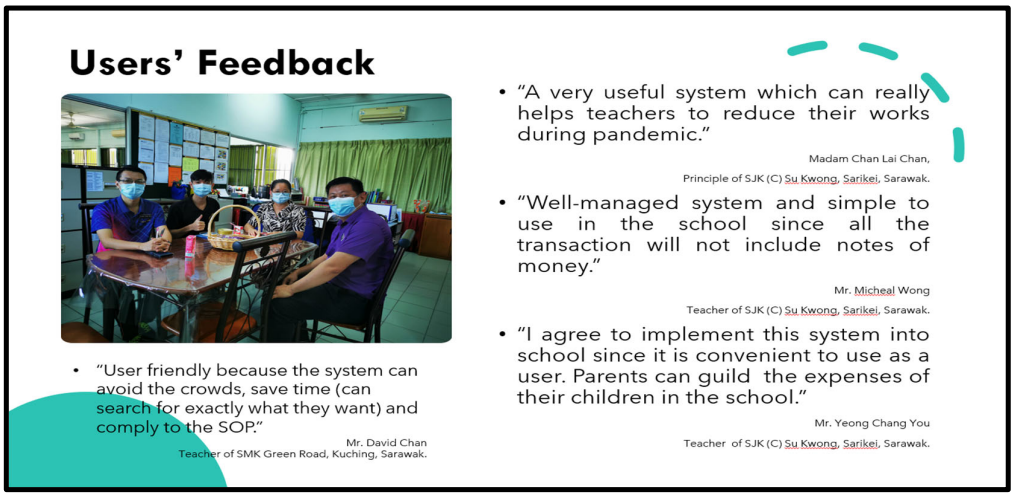


Figure 38: Positive feedbacks from teachers who tested the Food Order Assistant System

Conclusion

The Food Order Assistant system is an alternative to the current manual order system that will improve the process of food ordering in schools. It integrates the pre-order system through the website and real-time food order through the self-order kiosk, which both implements cashless payment. The system is ready to be implemented in the schools and allows students or teachers to order food online. The operational flow of the Food Order Assistant system is proven to save time and at the same time, helps the school to manage the SOPs during the pandemic. Another advantage of this system is that parents do not have to worry about their children as food order can be easily done from home. The system is also user friendly and easy to use with simple navigations. Besides that, the system accelerates the food ordering process by allowing food order to be done beforehand and fast payment method using RFID technology. The system would certainly help reduce administrative responsibilities of teachers especially in managing student food during pandemic. In addition, it encourages paperless practice as data is stored in the cloud and easily retrieved. This system also helps to avoid money loss, avoid food wastage and avoid long queues during food order. Other than that, it provides safe online payment, uses minimal device memory storage and provides an easy user interface to order anytime, anywhere and by anyone with an internet connection.

Acknowledgement

We would like to express our sincere gratitude to our facilitator, Mdm. Mitra Mohd Addi for the guidance and mental support provided to our group throughout the project until the success completion. A sincere thanks to the schools administrations, teachers, parents, students and former canteen owner of P19 cafeteria for participating in the interview, survey and providing suggestions to improvise the project.

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Smart Garbage Monitoring System using IOT

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Abstract: As workloads of students and teachers are increasing nowadays, dustbin cleaning tasks inside the classrooms are often forgotten. As a result, dustbins are always full and usually emit an unpleasant scent in the classrooms. This may contribute to unconducive learning environments and degrade teaching and learning performance. Therefore, this study proposes to implement a smart garbage monitoring system, which provides remote garbage level monitoring via mobile phone application, dustbin-emptying tasks scheduling through web application, and notification features for teachers, as well as for students who do not have access to mobile phones in the classroom.

Keywords: *Garbage Monitoring; IoT Smart Classroom*

Introduction

This paper discusses the project carried out for the Capstone Project. Our project was based on the theme given to us, "Smart School". Hence we decided to make teachers of various backgrounds as our target for our survey purpose. Based on the STEEP analysis we made earlier, we found many essential information that are very vital in completion of our project. Importantly, we found that STEEP analysis has brought positive impact in terms of social, technology, economy, environment, and politics. In terms of social aspects, it is user friendly. This is a very simple project to use, as it doesn't require any high end knowledge on technology or such in order to operate it. Besides that, it encourages students to maintain cleanliness in the classroom which indirectly nurtures good ethics among students. On the technology aspect, this product takes the classroom environment to the next level by the implementation of technology features such as IoT. Therefore, the classrooms' environment would be more conducive for teaching and learning purposes.

In terms of economics, it is a low cost device compared to the cleaning robots in the current market, which are highly cost to be afforded. Moreover, in order to operate this product, only AAA batteries are required which are user friendly, low cost and sustainable for battery replacement. In the environment sector, this product provides a sustainable classroom environment. It drastically reduces electricity consumption as it just uses batteries instead of consuming from power points. Lastly, in terms of the political sector, our project here actually In line with the Digital Government Transformation Action Plan (11th Plan). This product is really in accordance with the government's idea of introducing "technology" as a subject as part of the education syllabus to meet the Industrial Revolution 4.0 (IR 4.0) demands.

Project Objectives

The main objective is to implement a system for remote garbage level monitoring, dustbin-emptying task scheduling and notification for both teachers and students. This project was made to fulfill the requirements and the needs of our target users. The project aims to solve the problem statement we obtained from the survey we carried out through Google Form which was given out to our target users using social media. Furthermore, this project also aims to ensure the cleanliness of the class besides given the students early exposure to IoT features. Besides that the teachers could also benefit in terms of utilizing the technology which is growing very fast daily.

Design Statement

In week 3, we have discussed and met together through an online meeting to draft the design statement of the user in school to solve one of the main problems that we have collected from the google form survey and problem statement above. First, we design a profile that focuses on a teacher in school in the middle age who is a very dedicated teacher in school to ensure all students could study in the conducive environment. In addition, the teacher is always concerned about the students to understand all his teaching without any other disturbance during class especially the cleanliness in class.

The specific problem that the teachers experience during teaching is stress in monitoring student's progress or work. They also burden students with incomplete assignments and can't control the students to perform the cleanliness task according to the duty roster in each class. In order to solve that paint problem, the teachers in school need the system that can monitor the students' work or progress during the end class session and monitor them to cope with the learning activities in the class. In addition, the teachers also need the system that can ensure the students perform their clean task every day.

Finally, we have concluded and chosen a final design statement that can help the teacher to monitor and ensure the students to perform the cleanliness activities in the class according to the duty roster. We believed that a clean system in class can improve the learning activities and conduciveness in class.

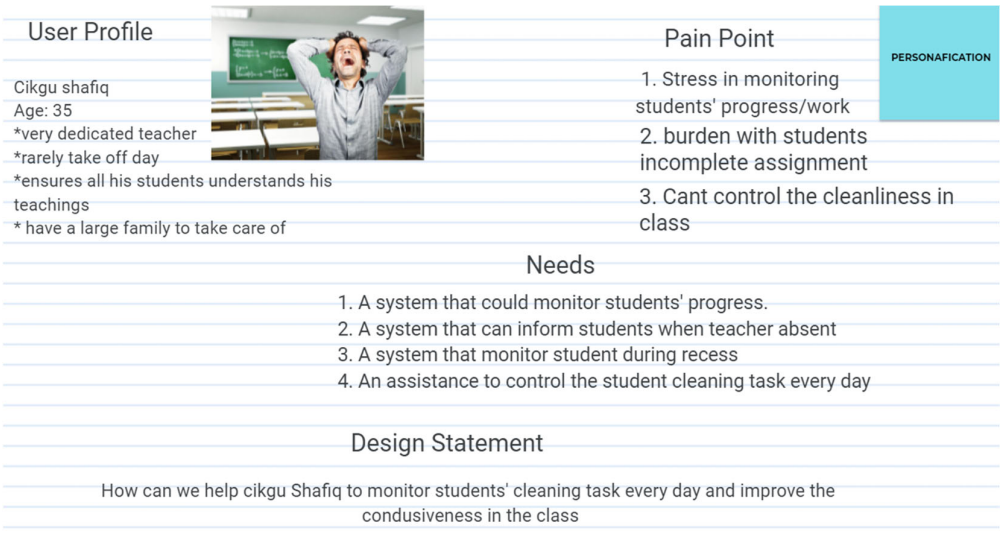

Figure 1: The design statement to solve user's paint problems

Conceive-Design-Implement-Operate Approach

Every project that is titled 'Smart' will be associated with the Internet of Things (IoT) or at least an Internet connection. 'Smart School' is growingly popular and even the Government's 11th plan is in conjunction with our project. It is very vital to give early exposure to students, and by doing so we could eventually cope up with the trend. The new generation would realize that technology is not only about smartphone and fancy gadget, it is way more than that and it is endlessly growing

Conceiving

I

In order to produce a product where it would really be a solution for the problems faced and to satisfy user needs, we created a form to conduct a survey through that form.

Google Form Survey

A survey was conducted by creating a questionnaire in google form. The target users for this survey were teachers from school, college and university. This survey was distributed to teachers through social media.At the end of the survey, there were 66 responses collected in a week. The respondents were mostly teachers from primary school with a total of 60.6% and 30.3% were from secondary schools teachers.

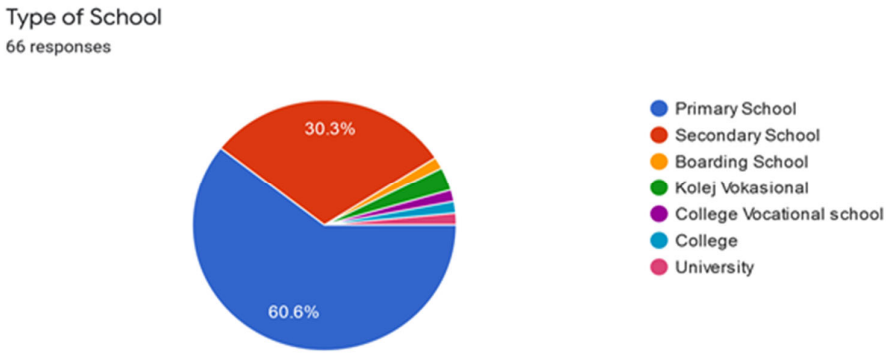

Figure 2: Type of School

Most of the teachers have faced problems while teaching in the current environment. The result of the survey showed that 93.9% of the teachers agreed that the facilities and learning environment must be improved drastically.

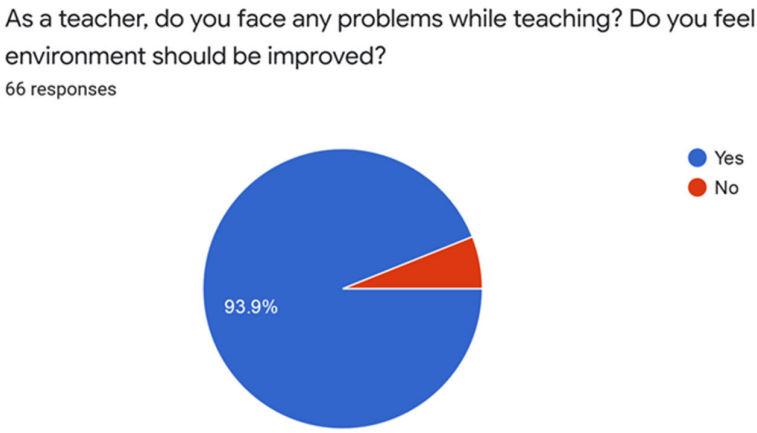

Figure 3: Pie Chart Of question about problem and facilities and learning environment

The type of cleanliness system that needs to be improved in the school based on the result from the survey showed that 60.6% of the teachers want a clean monitoring system and 21.2% want a smart dustbin while 12.1% Automated mobile vacuum.

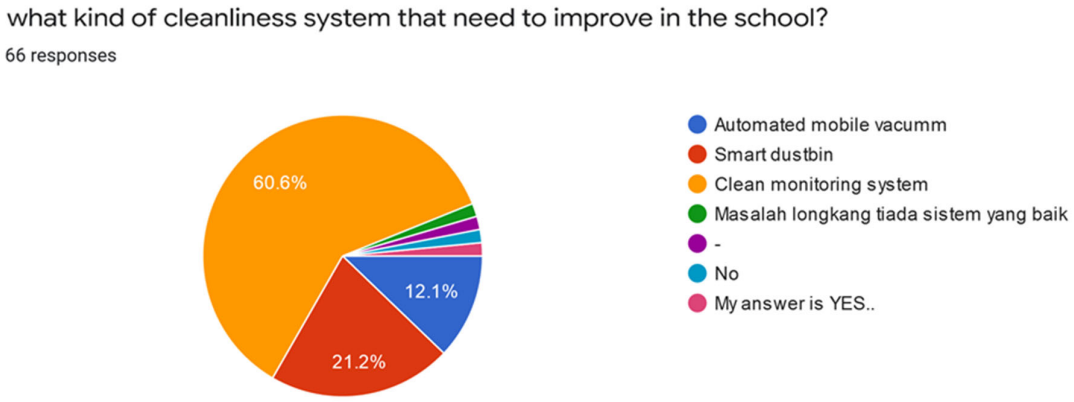

Figure 4: Pie Chart of question on type of cleanliness system

The data from the survey have been collected and analysed. From the analysis, most of the teachers agreed and want the cleanliness system to be improved or implemented in the school. Then the data were used to create an idea to propose a project that will satisfy the target users.

Personification and Design Statement

Problem Statement

- Students are always occupied with other class activities
- Students tend to miss out classroom tasks such as classroom cleanliness.
- Dustbins are often full and give unpleasant smells and make the environment less convenient for classroom activities.

Expected product outcome

- This product will help teachers, especially classroom teachers to monitor their student work and assign their student based on duty roster as the name of student will be shown in the Blynk App.
- It drastically improves the cleanliness of the classroom and indirectly makes the students to be more disciplined.
- Product is affordable and user friendly.

STEEP Analysis

Social	• Make it easier for teachers to control the student's attitude • Encourage students to be more discipline • Encourage students to maintain cleanliness in the classroom
Technology	• Make class more conducive for teaching and learning processes by implementing digital aspects on a daily basis. • Utilize IoT technology among students and teachers.
Economy	• Provide an affordable system that school could buy with a low budget. • Cut electric cost of the school
Environment	• Reduce electrical wastage • Create a conducive classroom environment • Improve classroom cleanliness
Politics	• In line with the Digital Government Transformation Action Plan (11th Plan) • Works in accordance with the government's idea of introducing "technology" as a subject as part of the education syllabus to meet the Industrial Revolution 4.0 (IR 4.0) demands. (https://www.nst.com.my/news/government-public-policy/2019/03/467395/govt-look-introducing-technology-subject-education)

Implementing

Our project for capstone is a smart dustbin, which could monitor and at the same time notify when the dustbin is full with a special feature of a student's name who are in charge to clean the garbage being notified together and displayed with the particular day. The detailed process flow was explained in the methodology section. Firstly, we finalised components and softwares for our project. Then upon segregation of the task, we progressed further. The web based application was then developed and at the same time the coding in Arduino IDE was also done. The codings were meant to detect the ultrasonic sensors and the displaying at the LCD display. The next part will be where the compiling of all the components and the software into a final product. The final part will be to configure in the Blynk mobile application for mobile monitoring.

Operating

In order to configure the web application, the essential code and procedures were shown in the Appendix. The coding in Arduino IDE were also provided in the Appendix.

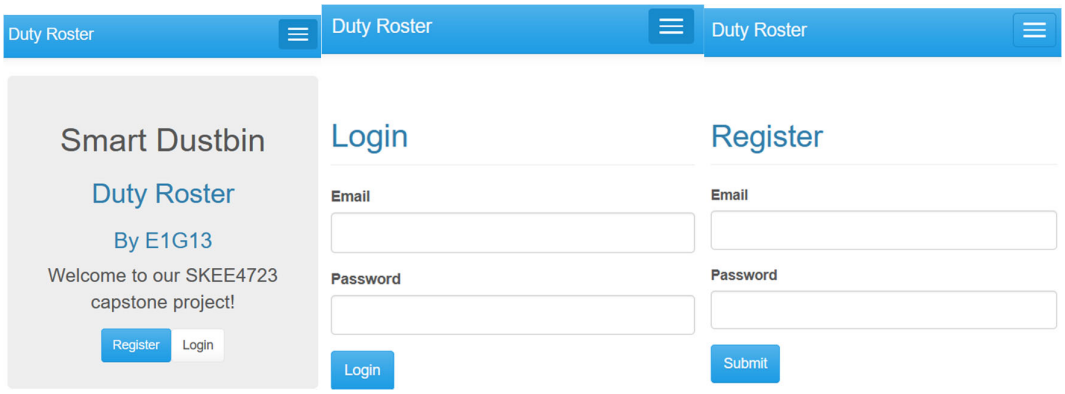

Figure 5: The Login interface looks like in the web application

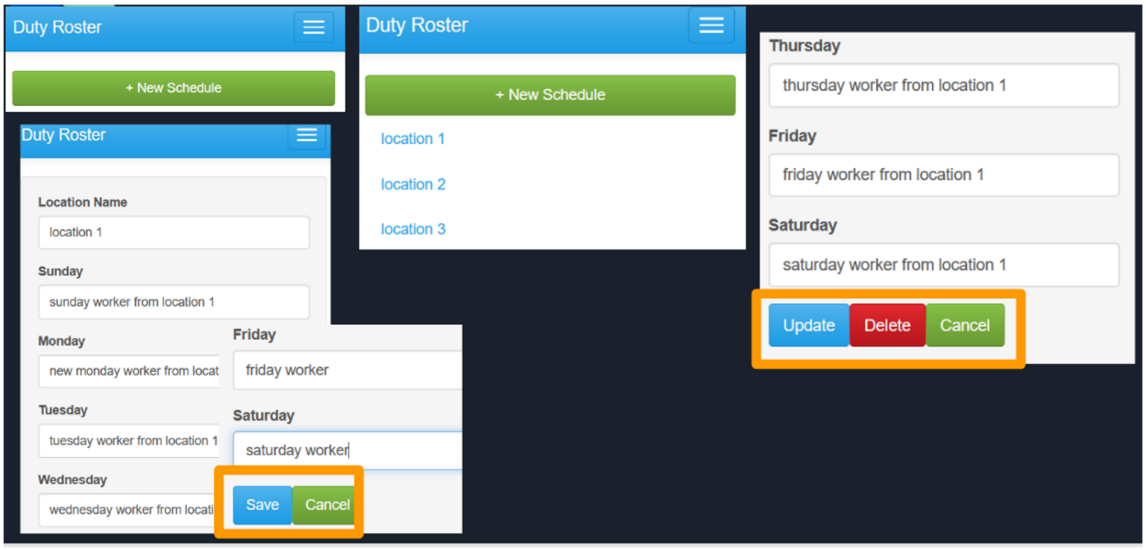

Figure 6: The interface of the web application where users can add,view,remove the schedule

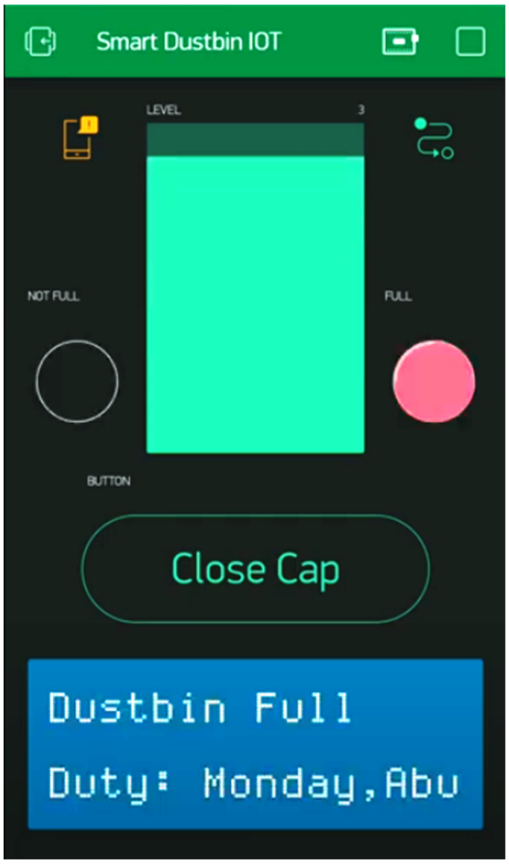

Figure 7: The display interface in the Blynk application when the user receives notification when the dustbin is full.

System Flow

The system flow has been designed from identifying the user's problem to producing the product that can be implemented at the user's place. The flow diagrams have been created as a project plan to show the overall system in order to produce the complete prototype. The electronic components have been determined to produce the complete system and we also designed the connections that include the main board, power supply, sensors, actuator, and the dustbin itself. The system has an ability to measure the level of garbage to help the users monitor the dustbin and will get the notification when the garbage is full. In addition, the system can be linked with a duty roster to help the students performing their cleaning task every day.

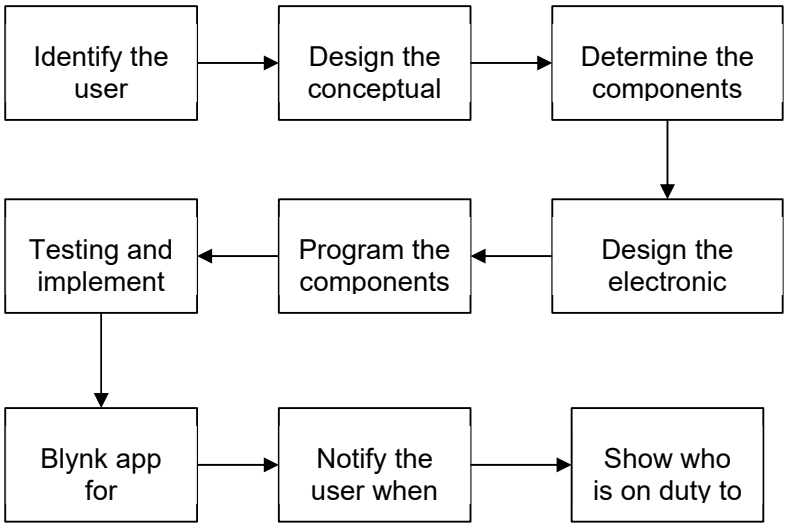

Figure 8: The Flow of the System Design

System Overview

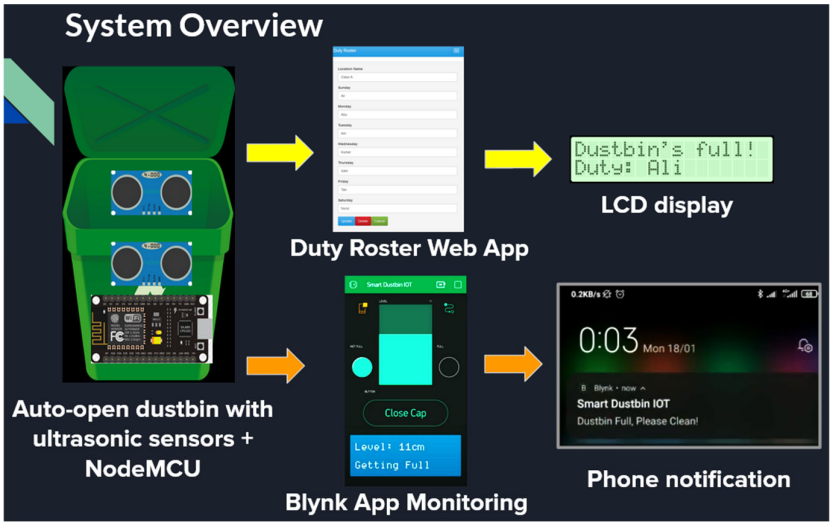

Figure 9: System overview

The system consists of three main components, which are auto-open dustbin, blynk app, and duty roster web app. Firstly, let us discuss the dustbin. The dustbin uses one of its ultrasonic sensors to sense approaching students so that the lid can be opened automatically, which is good for hygiene. The other ultrasonic sensor is used to sense the garbage level inside the dustbin. The sensors' signals are processed by NodeMCU, which is a WiFi-enabled microcontroller. NodeMCU will update the garbage level information to the Blynk app.

Next, the Blynk app will display real time updates about the garbage level. If the garbage level is full, the app user will be notified via phone notification. The third component is the duty roster web app, which is where teachers can schedule students' dustbin-cleaning tasks. The web app supports scheduling for multiple locations. Then, when the dustbin is full, NodeMCU can look up the schedules and print out the name on the LCD display as a notification for the student, since students are not allowed to use smartphones inside a classroom.

Circuit Design

The circuit design for this project consists of a nodemcu, ultrasonic sensor set,servo motor set, lcd, regulator set, push button set and led set. Each part has its own functionality. The main part was nodemcu. This nodemcu will act as microcontroller and open source IoT platform which helps to connect the prototype with web app database and blynk app. The nodemcu pins were connected with other parts at the correct pins as each pin has its own specification. There were two ultrasonic sensors used in this circuit. The first sensor was used to detect the distance of users from the dustbin and create an automatic open dustbin. As the distance decreases until a set value, this sensor will trigger the servo motor. The servo motor will open and close the cover based on the data from the sensor. The second sensor was used to detect the distance of the garbage from the cover. This was used to monitor the level of garbage.

The lcd part was used to display the level of garbage. The data was taken from the ultrasonic sensor part. Every change in the distance of garbage will be directly displayed on the lcd. This lcd also displayed the name of the student that was on duty. The data of the student duty roster was taken from a web app database created. Then the regulator set was used to supply the source to the lcd. In this regulator part, two AAA size batteries were needed. Lastly the push button and led set were used to test the circuit functionality.

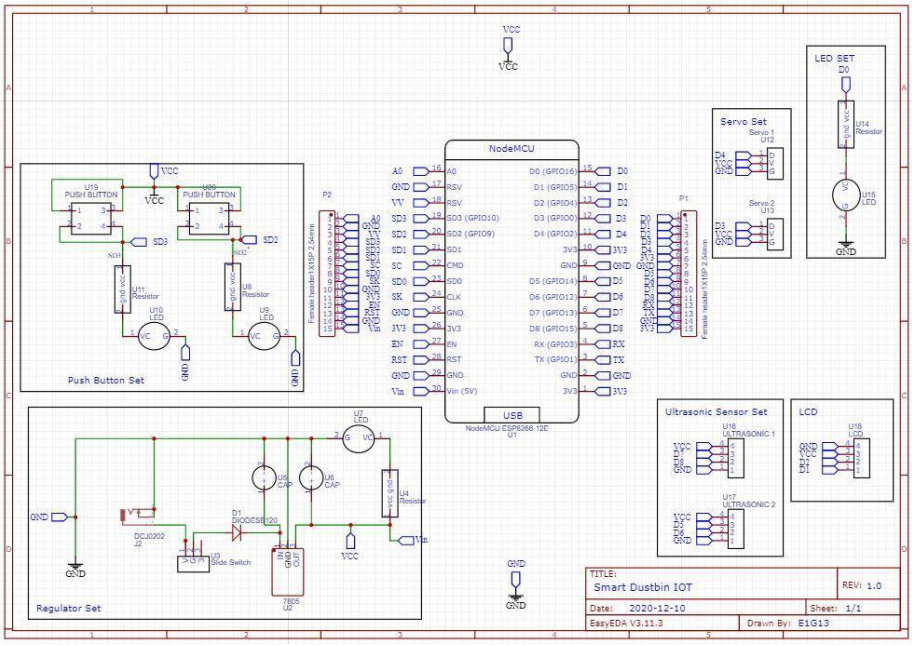

Figure 10: The circuit design of the system

Remote Garbage Level Monitoring

Remote garbage level monitoring is made possible using the Blynk app. Arduino IDE was used to code in order to interface Node MCU with the Blynk application through Blynk server. For this product,we designed such an output that has 4 stages, namely "Empty", "Half level", "Almost Full" and "Full". A notification will be sent to the class teacher's smartphone(installed with Blynk application) when the dustbin is full, together with the rubbish level,and yes most importantly the student's name who is in duty to clear the dustbin. The output interface in the Blynk applications are as below.

Empty Half level

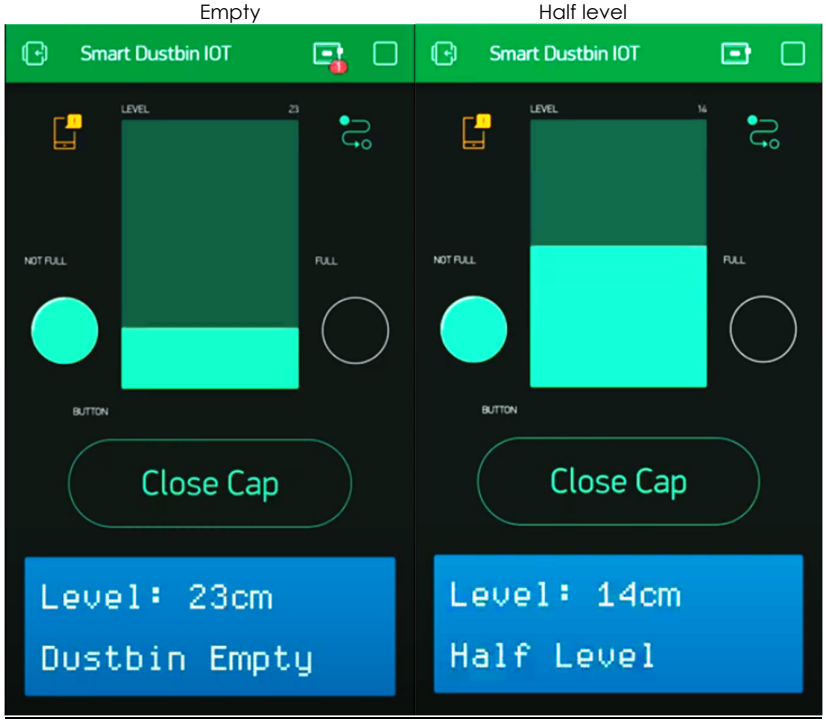

Figure 11: Remote Garbage Level Monitoring for Dustbin Empty and Half Level

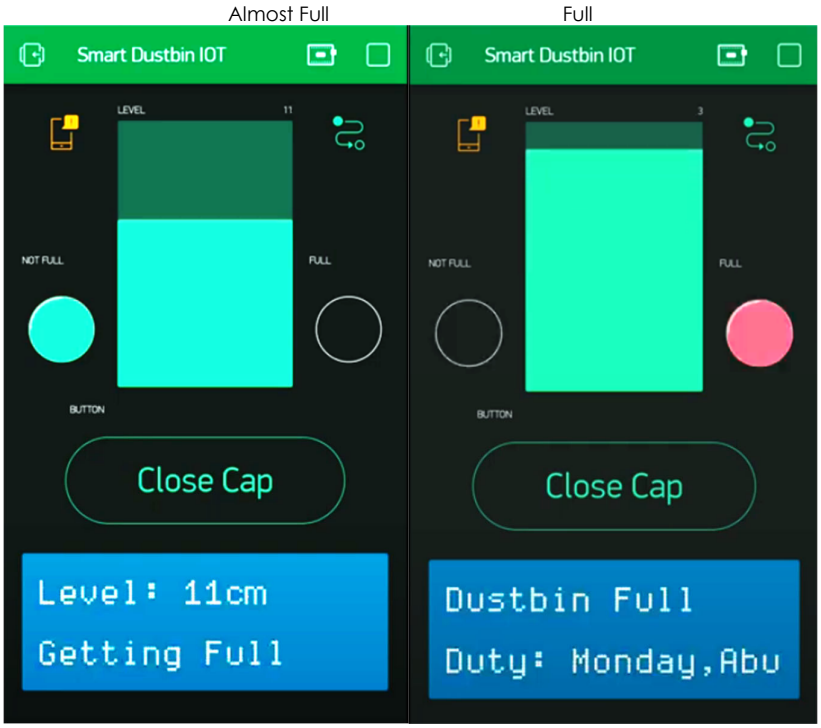

Figure 12: Remote Garbage Level Monitoring for Dustbin Getting Full and Dustbin Full with display who is on duty on that day

Dustbin Emptying Tasks Scheduling Web App

In order for NodeMCU to refer to the schedules in the web app, the web app provides each user with a unique API link, which can accept the location name in its query. NodeMCU only needs to send a HTTP GET request containing the query to the web app server, then the name of the student who is on duty on that particular day and location will be returned as a JSON response.

This method of handling schedules ensures that there is no hard-coding of schedules into the NodeMCU. The schedules are totally user-friendly in the sense that the schedules can be edited without touching any codes in the NodeMCU. All of the functionalities of adding, editing, and deleting schedule can be done online in the web app. When the students in a current classroom advance into another class, teachers only have to update the schedule in the web app. In short, a NodeMCU needs only be programmed once, and used forever without even needing the users knowing how to program it.

Circuit Board Printing

This project used a printed circuit board (PCB) to minimize the use of jumper wire. The use of the PCB helps to overcome the connection issues and increases the neatness of the prototype. For this project, the PCB was designed and ordered online on a website of a company from China. This company name was JLCPCB. The first step to order the PCB was to put the designed circuit of the system on the company websites. This circuit should be checked as the company just helped to print the circuit on the board. After putting the circuit, a PCB fabrication file (Gerber) will be created. Then the normal step for ordering online such as choosing the quantity and size.

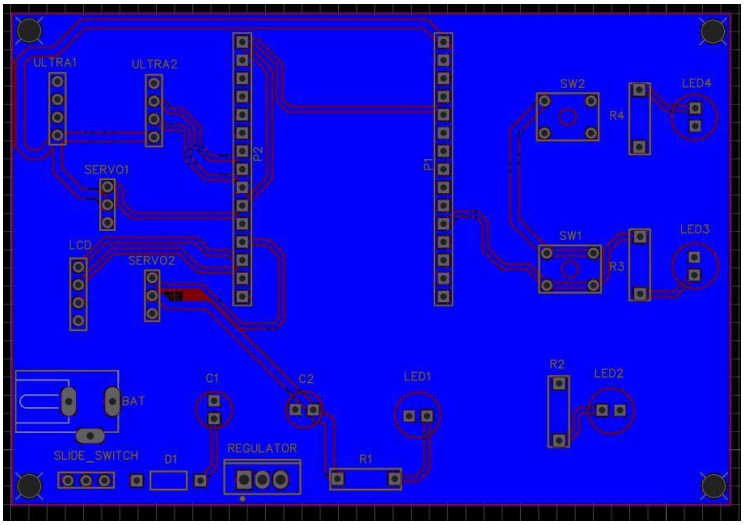

Figure 13: Printed circuit board

Dustbin Design

The design of the smart dustbin was proposed and implemented according to the suitability of the system to make it reliable and function well. This product prototype must be suited with all the components installed including the sensors, microcontroller, PCB, power supply, and wires. The ultrasonic sensor reading is very sensitive with any objects, so that the wires and all components need to manage well to ensure the system can give accurate data for monitoring purpose and calling the database when the dustbin is full. The design product was started with drilling a hole for a specific dimension to install the (20x4) LCD Display and Ultrasonic sensor and ensure the components are suited well in the required holes. Then, put the other sensor in the cup and stick together with the dustbin lid for measuring the level of garbage.

Other than that, the microcontroller (NodeMCU) with main board and power supply was put in the garbage and covered with a piece of paper to avoid the sensor measuring the wrong value instead of garbage level. Lastly, the wires were placed at the edge of the dustbin and managed properly through each connection from the main board to all required components. Then, the servo motor for controlling the auto open-close dustbin lid was stuck on the dustbin and attached with rope.

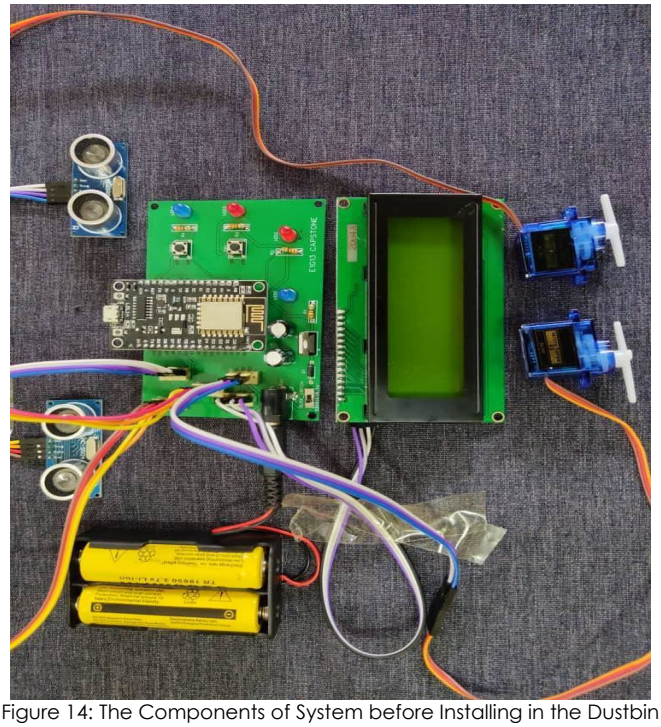
Figure 14: The Components of System before Installing in the Dustbin

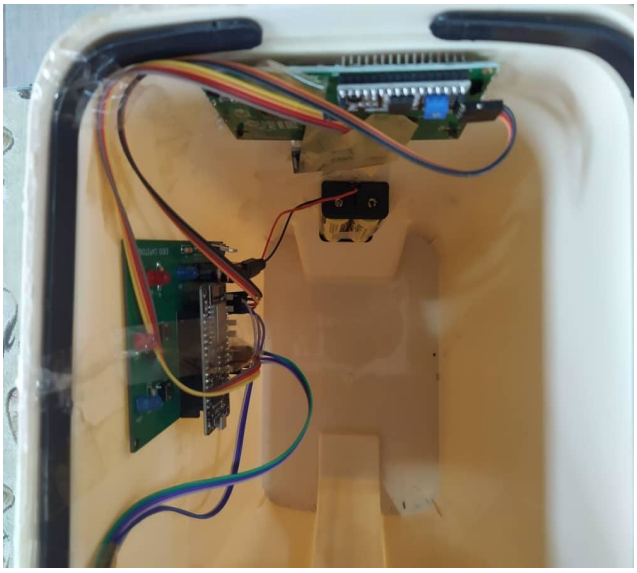

Figure 15: Installing all the Components and stuck to the Dustbin Wall

Figure 16: Ultrasonic sensor stick on the Top of Dustbin Lid for Measure the Level of Garbage

Figure 17: The Full product after Installing all required Components

Dustbin-Emptying Scheduling Web App

There are many technologies that can be used to make a web app. Instead of using old technology like LAMP stack, in this project, MEAN stack is used, which is a popular choice among modern web developers. Basically, MEAN stack is a full-stack framework for web development based on JavaScript. MEAN stands for MongoDB, Express, Angular, and Node.js respectively. MongoDB is for database, Express is for backend API development, Angular is for frontend development, while Node.js is the run-time on which MEAN stack runs on. These four components are summarized in the image below.

Figure 18: Technology of making the web app and database

Database Design

Instead of using the traditional SQL database, for IoT applications, NoSQL is a more natural choice. In the traditional SQL database, the data sets are uniform, however, IoT applications usually require more flexibility in data modeling, so NoSQL is used. As more and more devices are able to connect with each other nowadays, the data exchange is hard to be uniformized, and having non-strict schema like in NoSQL ensures easier future extension. The NoSQL database used in this project is mongoDB.

```
_id: ObjectId("600aa00166efa800042c64be")
email: "de@graduate.utm.my"
password: "$2a$10$1VIJNjeFFIWjbJgi8yyuv.p19dQTzXL333HQRbwgr/51Qt6I8Sfy6"
apikey: "53a521005c9711eb91984bdc8d889730"
schedules: Array
  0: Object
      locationname: "Location 1"
      sunday: "Ali"
      monday: "Abu"
      tuesday: "A2"
      wednesday: "A3"
      thursday: "A4"
      friday: "Tan En De"
      saturday: "Syafiq"
  1: Object
__v: 0
```


Figure 19: The example of the structuring of the data for this project

When a new entry in the database is created, the entry will have a unique _id for retrieving purposes. Next, since the web app supports registration and login function, the entry contains email and password. Besides, there is an unique API key for each user. API key is used for verification when calling the API from NodeMCU. Take note that since passwords and API keys are sensitive information, they are encrypted before storing into the database. The logic files for handling passwords are placed under the config folder.

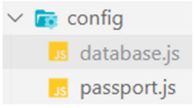

Figure 20: The config folder for handling password

Lastly, we have an array containing objects which are basically each schedule made by the user. Each schedule consists of location name as well as the name of students on duty for each day.

All together, the schema for the data is as shown next.

```
const ScheduleSchema = mongoose.Schema({
    locationname: { type: String, required: true },
    sunday: { type: String, required: true },
    monday: { type: String, required: true },
    tuesday: { type: String, required: true },
    wednesday: { type: String, required: true },
    thursday: { type: String, required: true },
    friday: { type: String, required: true },
    saturday: { type: String, required: true }
},  { _id: false });

const UserSchema = mongoose.Schema({
    email: {
        type: String,
        required: true
    },
    password: {
        type: String,
        required: true
    },
    apikey: {
        type: String
    },
    schedules: {
        type: [ScheduleSchema]
    }
});
```

Figure 21: The schema for the data

The files related to database schema and logic are placed in the folder named 'models', as in the model (M) in MVC architecture.

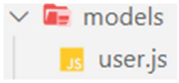

Figure 22: The schema for the data

Backend Development

The backend development has two functions. The first function is for the use of the web app, such as determining which page routing, registration, password authentication, and logging out users. The second function is for processing the incoming HTTP GET requests made by NodeMCU and sending back responses. Based on the two functions, the codes are split into two .js files for maintainability. They are placed in 'routes' folder since they handle routing of the requests.

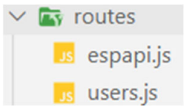

Figure 23: The routes folder for handle routing requests

Frontend Development

Frontend development's main purpose is to provide an user-friendly interface for end-users. In this project, the main components of frontend are home page, login and registration, duty roster editor, and dashboard for getting the API link.

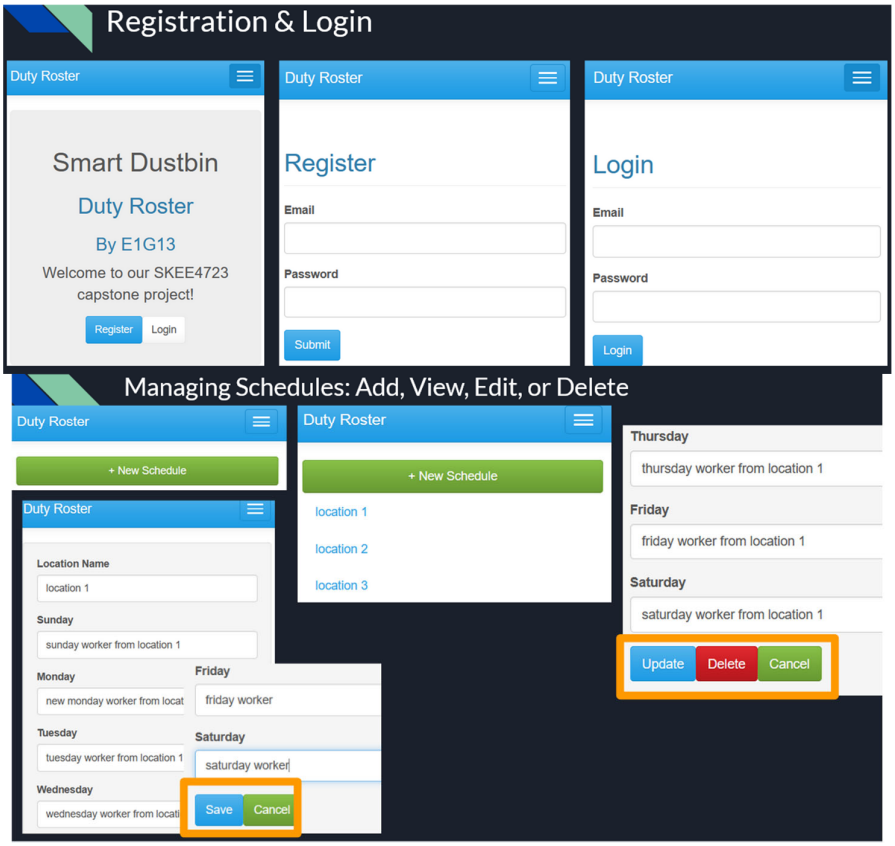

Figure 24: The frontend development interface

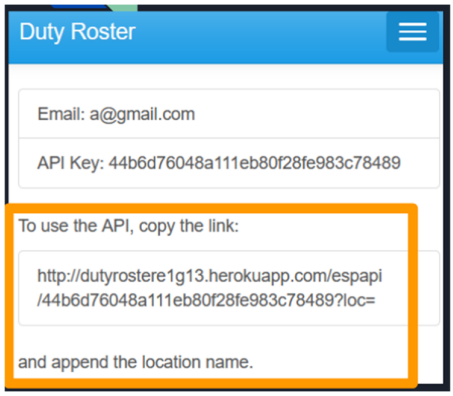

Figure 25: The API key of the database

The frontend files are placed under the folder 'app/src'.

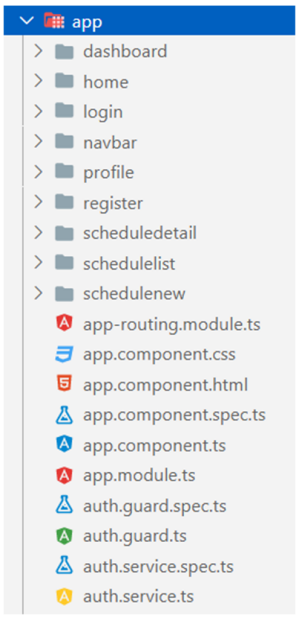

Figure 26: The frontend folder

Notice that the three main file types used for frontend development are HTML files, HTML files, and TypeScript files. The HTML files specify the structure and content of the web pages. On the other hands, HTML files need to be decorated using CSS files. Lastly, the logic behind the frontend elements contained in a page can be controlled using typescript files.

Hosting and Deployment

Without hosting, the web app developed can only be used in the development computer. To deploy the web app for use across the globe, we hosted the web app on Heroku.

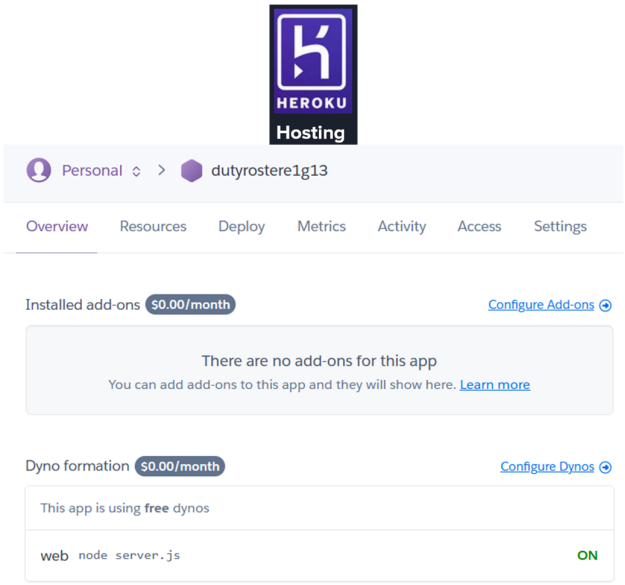

Figure 27: The deployment of hosting of the web app

System Comparison with Other Existing Implementations

Features	Our System	Secura Automatic Trash Can	Selvaraj & Chakrapani (2017)	Bhatt, Sharma & Chauhan (2019)	Contelligent	SmartTrash
Auto-Open Lid	Yes	Yes	No	Yes	NA	NA
Remote monitoring	Yes	No	Yes	Yes	Yes	Yes
Notification	Yes	No	No	Yes	Yes	Yes
Cleaning Task Scheduler	Yes	No	No	No	No	No

Many of the existing implementations of smart garbage bins or containers have monitoring features. However, simply knowing the level of the garbage inside the dustbins is not useful, if there is no one to clean them up anyway. Therefore, in our design, we added in the ability to schedule and notify who is going to clean up the dustbins. In addition, our system also considers students who are not allowed to use smartphones in the classroom. We devised a way to notify them without using smartphone notification, that is, via LCD display.

Power Consumption

On average, the NodeMCU draws around 50mA only. Using six AA batteries with 3000mAH each, it will take 3000mAH*6/50mA=360 hours=15 days of continuous usage before battery replacement is required. The power usage can be further minimized by putting NodeMCU into sleep mode after school time and during weekends. In that case, the effective operating time of NodeMCU is no longer 24 hours per day, but about 6 hours per day, resulting in 24/6=4 times longer battery life, which extends the battery replacement period to 15*4 = 60 days = 2 months. Another way of getting constant power supply is using a bridge rectifier to convert AC power supply into DC power supply for the NodeMCU. That way, we no longer have to worry about occasional battery replacement.

Cost Analysis

Last but not least, the system cost can be further minimized by producing in large quantities, just as the economies of scale implies. It is because we could minimise the cost wastage when we found an alternative cheaper component, and also when we buy components in bulk,we are able to obtain a cheaper price from the seller. The cost to produce one model would as depicted below:-

No	Component	Quantity	Price/piece (RM)	Total price (RM)
1	400 points half breadboard	1	5.00	5.00
2	HC-SR04 ultrasonic distance range finder sensor for Arduino	2	5.00	10.00
3	Sg90 Tower pro mini servo motor compatible with Arduino	2	9.00	18.00
4	Iot Lolin nodemcu ESP8266 wifi controller Board ESP-12	1	18.90	18.90
5	40P dupont male to female jumper wire 20cm	1	4.00	4.00
6	40P male to male jumper wire 20cm	1	3.90	3.90
7	5mm LED (red)	1	0.10	0.10
8	5mm LED (yellow)	1	0.10	0.10
9	2 ways PCB connector	2	0.50	1.00
10	DC plug 2.1mm	1	0.30	0.30
11	Resistor 330R 1/4W	4	0.10	0.40
12	Diode 1N4007	1	0.30	0.30
13	Electrolytic capacitor 25V 470uf	2	0.50	1.00
14	16 pin female headers	3	0.70	2.10
15	LM7805 voltage regulator	1	0.90	0.90
16	Desoldering pump	1	7.00	7.00
17	12C LCD interface module	1	4.50	4.50
18	LCD module 16x2 (green backlight) for Arduino	1	15.00	15.00
19	30cm female to female jumper wire	1	5.50	5.50
20	Resistor 1k 1/4W	1	0.10	0.10
21	Resistor 2k 1/4W	1	0.10	0.10
22	Arduino uno CH340G with cables included	1	17.00	17.00
23	PCB	5	$0.4(1.62)	6.55
24	2x18650 battery holder with DC jack model: CN-2X18650-DBJ	1	3.70	3.70
25	Straight female header 1x40 ways model: CN-PH-F140S	1	1.20	1.20
26	2021 PCB connector header(s) 4 ways model: CN-2021PS-04	2	0.20	0.40
27	2021 PCB connector header(s) 3 ways model: CN-2021PS-03	2	0.15	0.30
			TOTAL	RM127.35

Conclusion

In brief, this is a IoT based smart dustbin project that provides remote garbage level monitoring, duty scheduling, and notification features. The interaction between hardwares and software were made possible by using the IoT, the raw data obtained from the sensors were digitised when it reached the end user for a user friendly end product. The hardware used in this project are Node MCU, PCB board and Arduino Uno, meanwhile the softwares are Arduino IDE, Blynk application, and MEAN stack web app.

In the beginning, we conducted a survey to find out what are those problems faced by our target users. By using the data collected, we came out with possible solutions and performed STEEP analysis, to study the effects of this project towards social,technology,economy,environment and political sectors. Our final product works good and as expected as the prototype designed earlier. The Blynk displays are well coherent with the LCD display that was connected to the ultrasonic sensors.

Acknowledgement

We would like to express our gratitude to our dear supervisor, Dr. Nor Aini Binti Zakaria for her endless guidance and kindness throughout the project. Next we would like to mention our beloved friends for their help whenever it is needed and yes never leaving behind the panels of the prototype presentation who have helped us to rectify some of the complications and gave us ideas for us to progress even better.

References

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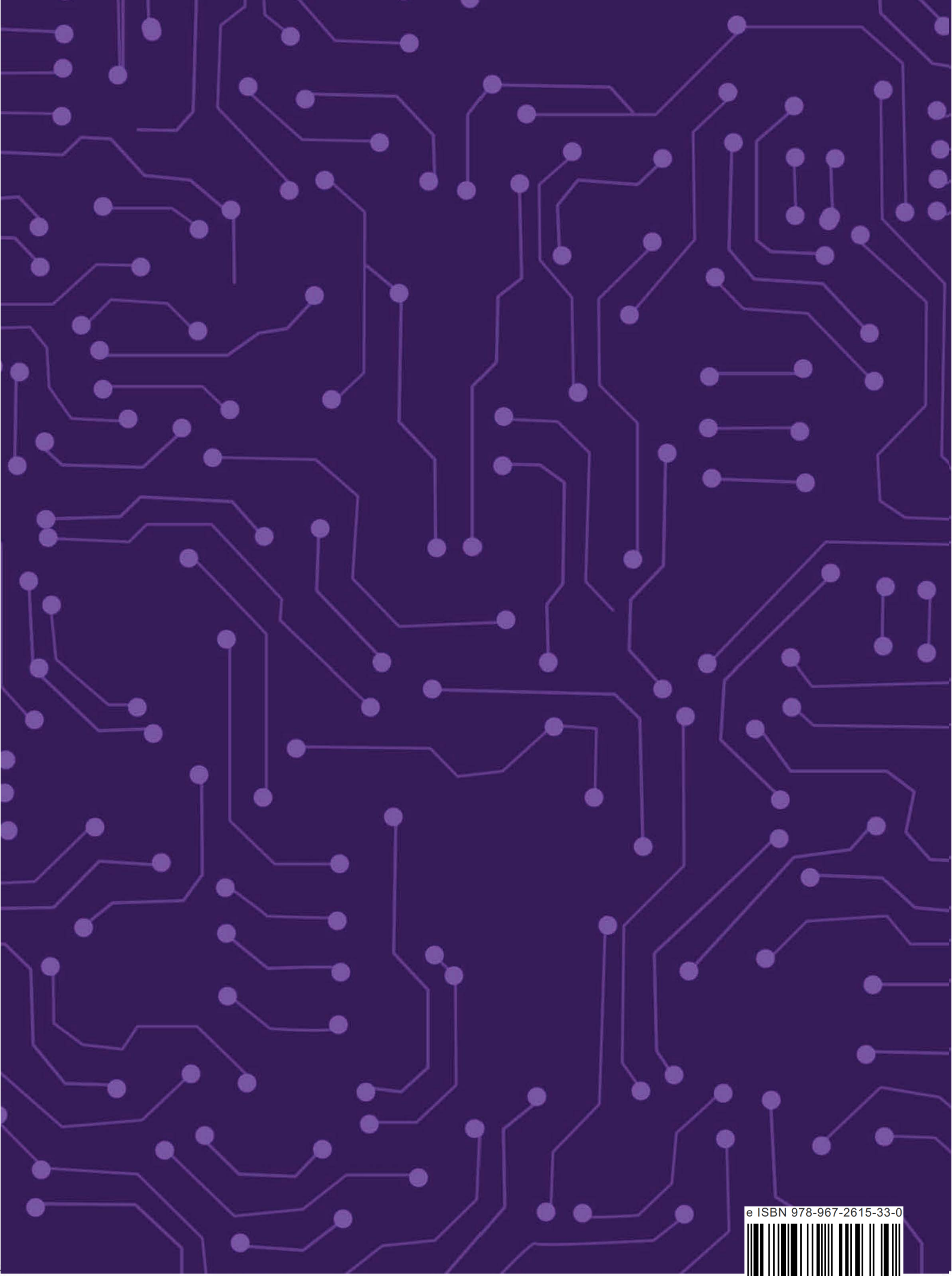

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