Smart Classroom for Electricity-Saving with Integrated IoT System

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Abstract. Electricity-saving can be achieved through the efficient use of energy, such as turning off lights and electrical appliances when not in use. Therefore, this work proposed the smart classroom for electricity-saving with an integrated IoT System to prevent wasting electricity in the classroom. Smart Classroom means that it will detect and count the number of students entering and exiting the classroom by using a sensor system automatically. The main objective of this work is to control the lighting systems and fans by using the IoT application and sensor system. This means that when the sensor is triggered, the sensor will send data to the Blynk application software using IoT to display the status of the classroom. This proposed work is also able to detect whether a classroom is available to use or not based on the presence of people. If the classroom is being used, the Blynk application software will show the lamp and fan are ON. Otherwise, the lamps and fans are OFF if there are no people in the classroom. The result successfully shows that if the first student entering the classroom, all the lamps and fans are ON. While, if the last student exiting the classroom, all the lamps and fans are OFF. This result also indicates that electricity can be saved if all appliances in the classroom are switch OFF at the right time.

Keyword: Smart Classroom, Internet of Things, Electricity-Saving

1. Introduction

Electricity is an essential element of a building's operating system. Electricity savings are also an important part of everyday life when the building's operating system is started. Buildings are responsible for energy consumption up to 40% [1]. With the increasing population in Malaysia, the education sector is also growing rapidly. Schools, teachers, and even IPTA and IPTS also have a large number of students and teachers. They use a large amount of energy in the classroom for in-class activities and fun activities provided in the classroom. But what is troubling in today's globalization is that inefficient use of electricity can negatively affect the humans and environment. Most of the electricity comes from non-renewable fossil fuels and therefore decreases over time. Even waste
generated by power plants will pollute the environment [2]. As such, with today's technology-rich, many of these technologies can help us all save electricity. Too much electricity is wasted in the classroom, with all the lights on and even the air conditioning installed even without students or lecturers. To reduce and even save electricity in the classroom, this Smart Classroom for Electricity-Saving project will automatically shut off the lights as well as the fan or air conditioning when the last person exits the classroom. Smart Classroom for Electricity-Saving is a microcontroller-based project designed for making a class fully automated using sensors and all-controlling is automated by using STC12C5A60S2 microcontroller. This project uses Infrared Sensor (IR Sensor) which will be used to detect students or lecturers entering or exiting the classroom. This project will be placed on the main door of the classroom to make it easy to keep track of the number of students and lecturers entering and exiting the classroom. At school, or in the industry, sometimes the fan and the lights are on even when no one is in the room or the area. The most common power wasting in an organization is thought to avoid power wasting in the classroom where more electricity is wasted due to negligence or student neglect [3]. Nowadays, education on energy saving at schools attracts attention to reduce energy consumption. In order to avoid wasting electricity, automatic changes to electrical equipment will be considered. This can be done based on electrical equipment control when someone enters the classroom and the electrical equipment automatically turn on, while, when the student or lecturer is exiting the classroom, the electrical equipment in the classroom automatically shut down. This system also can be integrated with the Internet of Things (IoT) system in order to ease the security or class taker to monitor the classroom.

The IoT refers to a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention. People start to find more easier or convenient solutions in daily life. Wireless technology is popular nowadays because it is convenient, easier to construct, and saves cost. Users can get the signal in the long-range without wiring. In this modern age, electricity usage is increasing with sophisticated and versatile electrical appliances. In fact, energy savings are also an important requirement when there is too much electricity in a building. In educational institutions, there are too many electrical appliances that students and lecturers need to use while studying but a great deal of electricity is wasted just because of our negligence. Most of the electricity in the classrooms, dorms and even the labs where electricity is the main focus is simply wasted. Therefore, this work suggested a smart classroom for electricity-saving with integrated IoT system. This system also can be used at any building, office, dorms or labs.

The paper is divided in following sections. In Section 2, the application related to the smart classroom are briefly discussed. Section 3, the methodology of this work is presented. The results and discussions are presented in Section 4 that shows the output of prototype of this system. For conclusion will be concluded in Section 5.

2. Literature Reviews

There are several works that have been developed based on smart classrooms and energy saving. For instance, [4] had proposed Energy Efficient Smart Classroom using Arduino Microcontroller. The sensors used can detect the intensity of light, humidity, temperature, and human presence in the classroom. The parameter sensors are used to control the lights as well as the fan in the classroom. This system is a good choice for energy savings and better results. The system is also used to determine the noise level at a given place and when the noise level exceeds the specified level, the SMS will be sent to the specified party. The disadvantages of this work are high complexity system and high-cost maintenance.

Meanwhile, Ansiya [1] had proposed the Automatic Classroom Lighting Controller and Energy Saving based on Microcontroller Unit’. This project uses the PIR Sensor to impress humans in the inner room in order to detect the movement of humans in something and electrical items such as fans and lights will light up. In addition, this project system also uses the existing campus cards given to students. The purpose of the campus card and also the IR Sensor is to detect the intensity of the light in the inner chamber. The microcontroller used in this project is the PIC 16F877A and other
components used are the Light Dependent Resistor (LDR) and also the PIR Sensor. If the PIR Sensor can detect the movement of humans in the inner chamber and also the LDR can detect the intensity of the light in the inner chamber, the signal will be sent to PIC 16F877A to compare the amount of light intensity that has been stored in PIC 16F877A. If the intensity is less than the amount saved, the lamp and fan will automatically be installed. Furthermore, Lanyun [5] proposed the Application of an Intelligent Device and Method for Detecting the Dynamic and Static Human Body in Energy-Saving Control of Schools. The Pyroelectric Sensor is used in the classroom to track student attendance and movement. If there are no students in the classroom, the lights will turn off automatically. This Pyroelectric Sensor can detect distances of up to 14 micrometers and this pyroelectric sensor can detect the movement of a student only. The equipment control module used in this project is the MOC3041 and SCR BCR20AM photoelectric coupling circuit. The MOC3041 photoelectric is to make the weak electrical conducting system separate from the powerful grounding electrical system. It helps to avoid electromagnetic interference. The SCR BCR20AM is a flexible switch and uses less power than the relay.

Moreover, Monika [6] proposed of Smart and Intelligent Power Saving System for Indian Universities. In this project, the PIR Sensor was used to detect people in the room or the corridor. These two PIR sensors have been installed at the entrance of the room to detect people coming in and out of the room. The microcontroller used in this project is Micro ATMega (ATMega 328P) used to control the process of this project. When PIR Sensor 1 followed by PIR Sensor 2 detect human movement into the room, the light will automatically turn on and when PIR Sensor 2 and followed by PIR Sensor 1 detect human movement out of the room, the light will automatically shut down. Additionally, Nandhini [7] proposed the Wireless Smart Class Room Using Embedded Technology based on the concept of energy-saving using ARM7TDMP Processor. The sensors used in this project are IR Sensor and PIR Sensor which is the IR sensor that will detect the students at the door of the classroom and PIR Sensor will detect the movement of the students when the students in the classroom. The RFID uses for the attendance purposes of the students. The GSM also used in this project to send a short message to the LCD. The disadvantages of this project are the high cost. Besides, Premalatha [8] proposed an IoT Based Smart Classroom. The main objective of this project is to provide an efficient learning environment. The smart degree booth model has been integrated by connecting the Raspberry pi to an LCD display and a smartphone-controlled via the internet. This model will carry attendance automation, display the tourer on a real board, online spare boxes, and take lecture notes to organize mass and make the class smart in real life.

Meanwhile, Patted [9] proposed an intelligent classroom automation system using a pic microcontroller. This proposed work aims to save energy with load control in the classroom and time management. Attendance monitoring also has been used based on fingerprint identification. Next, Rastogi [10] developed a smart electricity meter based on the internet of things. Several pieces of information have been focused such as the concept of smart meters, different types of communication, communication employing PLC, security and fraud detection, cost optimization, and data sets. Vignesh [11] proposed the IoT Based Smart Energy Management System by controlling the appliance using android devices. Anandakumar [12] proposed a smart home energy-saving system using IoT. Subsequently, Tsang [13] developed a remote control for the smart classroom with Bluetooth networks based on Apps, Bluetooth, Arduino, and PLC.

Furthermore, Dipali [14] proposed the IoT Based Smart Classroom with Google Assistant by considering the needs of rural students and their overall integration using ‘Internet of Things’ and ‘Think- Pair-Share’. The implementation of this type of smart classroom system in primary and secondary schools gave a huge impact on students. It will also enhance the teaching and learning experience. More recently, Sun [15] proposed the Development and Implementation of a Self-Optimizable Smart Lighting System Based on Learning Context in Classroom. Based on the previous works, there are no innovative works have been proposed for classrooms in order to save electricity by using an IoT system.
3. Methodology

The Smart Classroom for Electricity-Saving project is a project that uses to save electricity in the classroom. The objective of this project is to save electricity in the classroom by switching off the lamp and fan automatically when the class is not being occupied. The hardware components to be used in this project are the IR sensor, LCD display, and Node Microcontroller Unit (NodeMCU). The IR sensor used in this project only uses low power requirements that make them suitable for most electronic devices. The IR sensor is also capable of detecting motion in the presence or absence of light almost with the same reliability. This project is designed for the classroom that equipped with an IR sensor that senses the presence of student should make the electrical appliances like fan and lamp will switch on or off automatically. The LCD display will display the number of the student in the classroom. Besides the sensor, this project also using IoT by using the Blynk application. The function of the Blynk application in this project is to switch on and switch off the lamp and fan through IoT. If the IR sensor does not sense the student or lecturer, the Blynk application will show the light and lamp are in condition off.

Figure 1 shows the block diagram of this work.

![Block Diagram of Smart Classroom for Electricity-Saving](image)

Based on figure 1, the IR sensors which are IR1 and IR2 have been used in the smart classroom for electricity-saving. There two IR sensors will be placed at the door of the classroom for traced the students or lecturer enter and out of the classroom. The IR1 and IR2 are the same type and play the same roles which are to detect the presence of an object. Next, the function of the Blynk application in smartphones is to switch on and off the light and fan manually. If the lamp and the fan do not switch off after the class session, the Class Caretaker or Security Guard can turn off the lamp, and fan by using this application. The Blynk application will show whether the light and fan are switch on or off. Figure 2 shows the data flow diagram of this work. The diagram shows that the flow of data from NodeMCU to the Blynk. Then, after update data to the Blynk, the admin will receive the data. The overview diagram and mobile apps interface of the smart classroom for electricity-saving with integrated IoT system are illustrated in figure 3.
4. Results and Discussions
As mentioned in the previous section, the NodeMCU and IR sensors as the main hardware where the NodeMCU is an open-source Lua-based statement and development board specifically targeted for IoT-based applications. This includes firmware running on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware based on the ESP-12 module. The NodeMCU ESP8266 expansion board is equipped with an ESP-12E module containing an ESP8266 chip featuring a 32-bit Tensilica Xtensa LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. The NodeMCU has 128 KB RAM and 4MB Flash memory to store data and programs. High processing power with Wi-Fi / Bluetooth and Deep Sleep Operations feature make it ideal for IoT projects. The IR Sensor principle serves as a detection object sensor consisting of an IR Led and an IR Photodiode referred to as an Opto-Coupler. When the first person enters the class, the IR sensor 1 (IR1) will detect and the lights and fan will light up and the LCD will appear the number of people who have entered the class. When the last person leaves the classroom, the IR sensor 2 (IR2) will detect the last person and the lights and fan will turn off and the LCD will appear that the classroom is empty. The function of the Blynk app is to monitor lights and fans. If the IR sensor was unable to detect the last person, the person who has the application, for example, the Class Caretaker or Security Guard are able to monitor the light and the fan through Blynk mobile apps.
Figure 4 shows the prototype lamp and fans in the classroom. While figure 5 shows the Blynk mobile apps connected to prototype smart classroom with integrated IoT system.

**Figure 4.** The prototype lamps and fans in the classroom

![Prototype lamps and fans](image)

**Figure 5.** Blynk mobile software connected to prototype smart classroom

![Blynk mobile software](image)

Figure 5 shows the combination of the prototype classroom with the Blynk application. The lamps and the fans using 240 volts AC and the NodeMCU using 5 volts. Figure 5 also shows that the ‘number of students’ on the LCD display. The number of students shows zero because no student entering the classroom. Therefore, the lamps and fans in the classroom in condition switch OFF. When the first student entering the classroom, the ‘number of students’ on the LCD screen will increase and the Fans and Lamps will be switch ON automatically. The icons in the Blynk application also indicate that the lights and fans in the classroom are switched ON. There is no limitation for the LCD display to shows the number of students entering and exiting the classroom. Besides, if the last student exiting the classroom, the ‘number of students’ on the LCD display is decreases, and the Fans and Lamps will be switch OFF automatically. This Smart System also can be controlled and monitored through mobile apps. This will make it easier for Class Caretaker or Security Guard to check the classroom after office hours. The term of electricity-saving is to prevent the waste use of electrics if someone forgot or late to turn off the switch Fans and Lamps after using the classroom. This system becomes the main important role in era IR4.0 and can be applied in the real-time situation in the classroom. This system has been tested by using 6 students as shown in Table 1.
Table 1. Result of the Smart Classroom

| Number of Students  | IR1 | IR2 | Number Display (LCD) | All Appliances ON/OFF |
|---------------------|-----|-----|----------------------|-----------------------|
| Student_1 IN        | 1   | 0   | 1                    | ON                    |
| Student_2 IN        | 1   | 0   | 2                    | ON                    |
| Student_3 IN        | 1   | 0   | 3                    | ON                    |
| Student_4 IN        | 1   | 0   | 4                    | ON                    |
| Student_5 IN        | 1   | 0   | 5                    | ON                    |
| Student_6 IN        | 1   | 0   | 6                    | ON                    |
| Student_4 OUT_TOILET| 0   | 1   | 5                    | ON                    |
| Student_4 IN_CLASS  | 1   | 0   | 6                    | ON                    |
| Student_1 OUT       | 0   | 1   | 5                    | ON                    |
| Student_2 OUT       | 0   | 1   | 4                    | ON                    |
| Student_3 OUT       | 0   | 1   | 3                    | ON                    |
| Student_4 OUT       | 0   | 1   | 2                    | ON                    |
| Student_5 OUT       | 0   | 1   | 1                    | ON                    |
| Student_6 OUT       | 0   | 1   | 0                    | OFF                   |

Table 1 shows that if the first student entering the classroom, the IR1 will be activated and all the appliances in the classroom will be turned ON automatically. The LCD will be displaying the number ‘1’ which means there is one student in the classroom. Furthermore, the LCD will continuously count and display the number of students entering and exiting the classroom. While the IR2 will be activated if someone exiting the classroom and the number display on LCD will be decreased. When the last student leaves the classroom, the LCD will be displaying ‘0’ which means the classroom is empty and all the appliances will be turned OFF automatically.

Based on the results, electricity can be saved if all electrical appliances are shut down on time automatically after use. For example, if a classroom has four units of 1 horsepower air conditioner that use 860 Watts per hour is not turned off for 2 hours, the waste of electricity that occurs is as much as 6880 Watts. If the same thing happens again, then the electricity bill will be high. Therefore, this work was developed to reduce the waste of electricity based on IoT technology.

5. Conclusion
This work has introduced the era of advanced saving-electricity through sensors and IoT to make human life easier by designing an automated power controlling system for smart classrooms. Smart Classroom means that it will automatically detect and count the number of students entering and exiting the classroom. This automated power controlling project can save more electricity by using sensors. The goal of this project is to build an application that can transmit and receive signals using IoT. The results show that IoT technology can be used to bring improvements to classrooms appliances. In addition, this work is suitable and compactable in many types of places such as classrooms, homes, hostels, and halls. The implementation of this work will make life easier and save the cost of electricity. Here are some extracted points for advantages that have been achieved based on the objectives of this work. The first point is, save energy and save the environment. Secondly, automated smart classroom system to count the number of students entering and exiting the classroom using sensors. Lastly, a user-friendly system to monitor and control the classroom are easily done through mobile apps.

Acknowledgement
The authors acknowledge to Universiti Malaysia Perlis (UniMAP) for the funding and support of the research work under UniPRIMA research grant, 9001-00632.
References
[1] Jabeen A and Kumar D M 2016 Automatic classroom lighting controller and energy saving based on microcontroller unit. *International Advanced Research Journal in Science, Engineering and Technology*, 3(7), 201-203.
[2] Villanueva A T and Concepcion A U 2018 Energy Conservation System for Classroom using Microcontroller: An Innovation. *Available at SSRN 3429842*.
[3] Kuzume K, Tabusa T and Sawa H 2016 Electric Power Saving Awareness System at School Using ICT. *MATEC Web of Conferences*, 55, 3–8.
[4] Patil B K, Badguitar R D, Nil N L, Suryawanshi S N, Patel D C and Pratima P 2018 Energy Efficient Smart Classroom. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, Volume 6, Issue VI, 85–89.
[5] Shao L, Yang Z and Zhang W 2017 The Application of Intelligent Device and Method for Detecting Dynamic and Static Human Body in Energy-Saving Control of Schools. *Procedia Engineering*, 205, 4017–4021.
[6] Lakra M, Kiran K V and Chinara S 2016 Design of Smart and Intelligent Power Saving System for Indian Universities. *First International Conference on Information and Communication Technology for Intelligent Systems*, Volume 1 (pp. 245-253). Springer.
[7] Nandhini S K, Sankar D, Geetha R and Sudhakaran M 2017 Wireless Smart Class Room Using Embedded Technology. 3(2), 1855–1865.
[8] Premalatha D B and Krishnan J H 2020 Iot Based Smart Classroom. *International Journal of Scientific & Technology Research* Volume 9, Issue 02, February 2020.
[9] Patted M, Muley S and Panda D 2016 Intelligent Classroom Automation System Using Pic Microcontroller. *Journal of Research in Engineering and Technology*. Vol 5,(6), pp 154-160.
[10] Rastogi S, Sharma M and Varshney P 2016 Internet of Things based smart electricity meters. *International Journal of Computer Applications*, 133(8), 13-16.
[11] Mani V, Gunasekhar A and Sankaranarayanan S 2017 Iot based smart energy management system. *International Journal of Applied Engineering Research*, 12(16), 5455-5462.
[12] Anandakumar M, Gunasekaran R, Singh E D, Saravanan P and Sangeetha M 2017 Smart Home Energy Saving System using IOT. *Global Research and Development Journals*, 2(5), 102–108.
[13] Tsang T and Kit L M 2018 Remote Control for Smart Classroom with Bluetooth Networks. *International Journal of Computer Science and Information Technology*, 10(4), 65–78.
[14] Borse D D and Patil P S 2019 IoT Based Smart Classroom with Google Assistant. *International Journal of Control and Automation*, 12(5), 226-237.
[15] Sun B, Zhang Q and Cao S 2020 Development and Implementation of a Self-Optimizable Smart Lighting System Based on Learning Context in Classroom. *International journal of environmental research and public health*, 17(4), 1217.