Design Of Smart Classroom System Using RFID Technology: Energy Saving Tool

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Abstract: - A high percentage of the budget of a higher educational institution (HEI) in the Philippines goes to electricity. Not only is this caused by high-power air conditioning units and laboratory equipment, but also by the lavish spending of electricity by the students for non-educational purposes. Ways to conserve electrical energy should be implemented. The use of a power-saving switch has been a practice at hotels, some households, and even schools. They are programmed to enable power only for authorized personnel. This also ensures no standby power of any appliance will be wasted. This study aims to develop a device that shall lessen power wastage. This is done by a power switch with Radio Frequency Identification (RFID) which only allows instructors to access a room, and turns on its power. The project prototype is installed in one classroom of the HEI. Feedback from 207 participants, both students and faculty members, shows that all are in agreement with this project but need minor improvements. Power consumption with and without the said prototype was compared and shows that power wastage without it is 7.81%. T-test was conducted from the data gathered from two different conditions with and without the system and showed that the installation of a Power Saving Switch using RFID has a significant difference in a room's power consumption.

Key Words: — ***Energy Saving, Power Consumption, Prototyping, RFID, Smart Classroom.***

I. INTRODUCTION

The advancement of technology in the Philippines is evidently seen all around us. Automation not only emerges at homes but also at schools and even in public places. Several sensors, modules, and programs are being used to industrialize the country. In fact, in 2018, the Philippines climbed a spot to 55th out of 82 economies traced in the Latest Technological Readiness Ranking published by the Economist Intelligence Unit (EIU). EIU analyst Anwita Basu further stated that though our country isn't as favorable as other countries when it comes to its technological situation, he believed that there will be steady progress in improving cybersecurity, creating e-government portals, and raising internet connectivity speed in the future years. A lot of simple yet remarkable technological advancements have been of great help in our country in making work easier faster, and more efficient [1].

Manuscript revised April 24, 2023; accepted April 25, 2023. Date of publication April 26, 2023.

This paper available online at www.ijprse.com

ISSN (Online): 2582-7898; SJIF: 5.59

Radio Frequency Identification (RFID) technology is one that is being implemented and developed in recent years. It has many applications in vehicles, identification systems, military, and security due to it being flexible and cheaper than other identification technologies [2]. It is an automatic identification technology used for retrieving or storing data on RFID tags through radio waves. One of its simplest implementations is found at hotels wherein instead of a key, a Radio Frequency Identification (RFID) key card is used to open a room. Once a key card has been placed, it automatically turns on the power and when removed upon leaving, it turns off. Power surge protection is an efficient way of making sure that no appliance left plugged in will consume power, thus, promoting energy conservation.

Another remarkable development that's making its way is the Internet of Things (IoT). It is defined as "the networked interconnection of everyday objects" [3]. It allows different devices to be controlled through internet access. In this present time, anyone can find a Wi-Fi connection in different places in

urban areas, from coffee shops to libraries, and shopping malls to universities. The number of devices capable of connecting to the internet is also increasing at a rapid rate. This includes personal computers, laptops, PDAs, smartphones, smartwatches, and other handheld devices. Controlling appliances, storing data, and tracking location wirelessly is possible when these devices are connected to the Internet [4].
Attendance is considered a key factor for high productivity in a class. This does not only mean the students are present, but the instructors as well. It keeps track of the commitment they've put in to produce high-quality graduates [5]. Before the era of automation, a manual attendance system is being implemented where time cards were used. This type of recording attendance requires a lot of time and manpower. The integrity of the data is also in question because cases that are time written are not accurate or can be bribed to tamper [6]. Attendance tracking for instructors can also be a key to fault-finding whenever equipment is damaged or missing, or whenever appliances are left turned on. The administration can easily identify who is the last person who stayed in the room that may be held responsible for the incident [7]. Classroom security is a preventive measure of similar occurrences.

Power saving and management are essential. The development of power sources is continuous but at the same time costly. The demand for electricity in the Philippines almost doubled from the year 2000 to 2018 [8]. At the same time, the cost of power rate is increasing. In the year 2019, Meralco had a constant increase in its power rate from the months of October to December. Saving power essentially means saving money. Currently, there are various ways of saving electrical energy like simply unplugging appliances when not in use or installing power-saving switches. A way to develop power-saving techniques shall be implemented not only in households but also in business establishments, public service agencies, and other facilities.

The locale of this study which is a state university aims to implement a procedure in the Austerity Measure Program under its Strategic Performance Management in relation to managing monetary assets in a smart way. A way to help the university on managing its finances wisely is by cutting down on the power being wasted. Power wastage is usually caused by appliances being left turned on or students staying in a room, utilizing its appliances and outlets, even without classes. A study regarding building a Smart University also showed that the power wastage of the National University of Computer and Emerging Sciences is up to 26.95% [7]. This is caused by the standby power of appliances not being turned off. One study also developed an automated door lock and electrical activation of laboratory rooms to save energy when the rooms are not supposed to be in use [9]. The same scenario happens in the locale of the study, especially during the free period for students where there are vacant rooms. In order to avoid this from happening, room access should be limited. The researchers believe that the implementation of this system would allow power wastage to be partially eliminated, thus, saving money.

To further determine if implementing the developed device would help in saving power, the following are the hypotheses of this study:
H_o: The installation of the power-saving switch and adding security access to a room through RFID technology has no significant difference to a room's power consumption as compared to having a manual breaker.
H_a: The installation of the power-saving switch and adding security access to a room through RFID technology has a significant difference to a room's power consumption as compared to having a manual breaker.

II. Methods

The study mainly focuses on providing a sustainable way of managing power to lessen the electric bill. The researchers applied the research paradigm presented in Figure 1. In conceptualizing the whole process of this research, the researcher adopted the Input-Process-Output (IPO) template. Energy consumption serves as the input of the study. Power wastage will be reduced because students will not be allowed to enter if no class is held. This limits them to not using the power for non-academic purposes. Lessening the power wastage means lesser power consumption and thus, less electric bill.

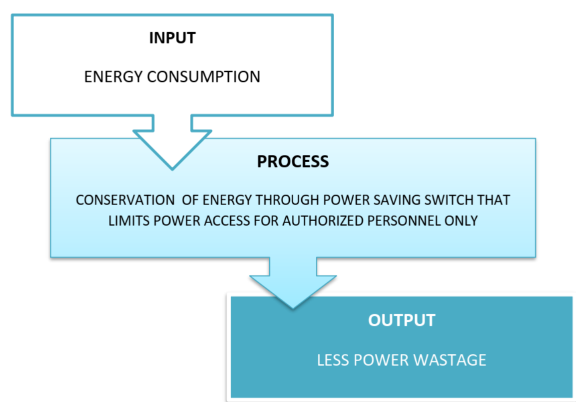


Fig.1. Paradigm of the Study

2.1. Prototyping

In developing the whole system, the prototyping model was followed because it is best used and applicable in a system wherein the requirements are changing [10]. To ensure that the final system would achieve the objectives of the study, the evaluation of experts would be obtained.

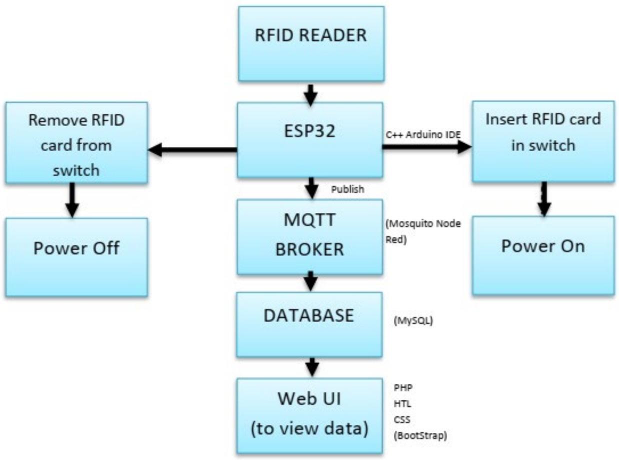
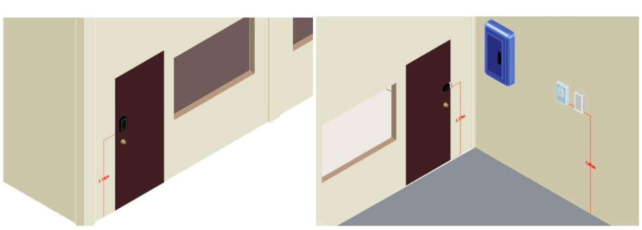


Fig.2. Block Diagram of Power Switch

The prototype hardware consists of three major components: the smart door lock, magnetic switch, with the RFID controlled by ESP32. An RFID registered to the instructors will be used to access the smart door lock. The ESP32 allows the connectivity of the data being transmitted by the RFID card to be stored in a database website. The block diagram of the prototype is illustrated in Figure 2. Basically, once an instructor inserts the RFID card on the reader, a signal is transmitted to the database containing the name and the time of login. After 30 seconds, access is given and triggers the relay to switch and turn on power. The same RFID card used in opening the door shall be placed on the card holder of this switch. This serves as the main circuit breaker. Manual switching on and off of lights, fan, and aircon are still followed. After a class finishes, the instructor shall remove the card which turns off the main power, assuring no power wastage. This also sends a log out signal to the database.



(a) (b)

Fig.3. Smart Door Lock Placement (a) Outside (b) Inside

Installation of lock is illustrated in Figure 3a. The power saving switch will be installed next to the panel that is easily accessible upon entering the room as shown in Figure 3b.

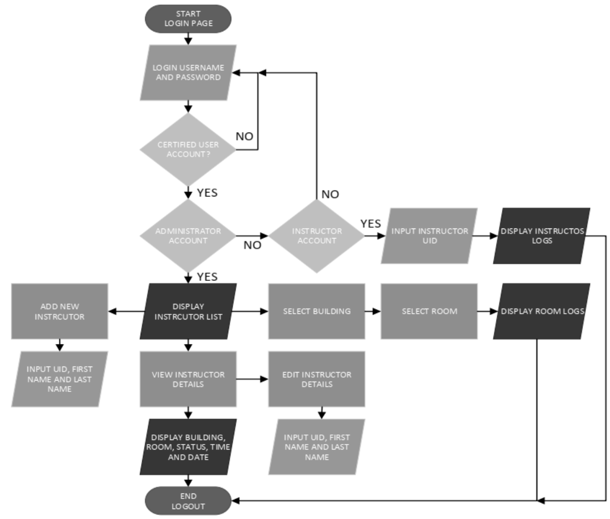


Fig.4. Flowchart of Database User Interface

The flow chart of the user interface shown in Figure 4 shows a systematic way of accessing each page of the database. The first page of the database user interface that shows when the address is visited is a login page that the administration only has access. After entering the username and password, the homepage will be displayed where the names of the instructor are shown. Searching a name of an instructor is also possible in this page. Clicking the name of an instructor will lead to the details page and will show the login and logout time and the room used. Adding a new instructor in the list is easily done through the add instructor page. The UID of RFID, first name and last name are information that are needed to be fill out. If wrong information was input, an edit information page is also available. There is also an option to select a specific room from a certain building. Instructor are also allowed to view their own logs by entering a preset username and password only for instructors and then entering their unique UID on the RFID card.

Node-RED is a graphic-based programming language built on Node.js. This made the creation of user interface easier by creating what "flows" where the program runs by. This is popularly used in making database servers and connecting various hardware devices. Node-RED establishes the connection between the ESP32 and the database. It is a programming tool that interconnects hardware devices through a browser-based editor [11]. Figure 5 shows the created flow for the system through Node-RED. The ESP32 on the test classroom as seen in the flow are connected to different nodes which are the different IDs that are registered to it. The database becomes easily expandable by adding similar nodes but with a different device connected to the same network.

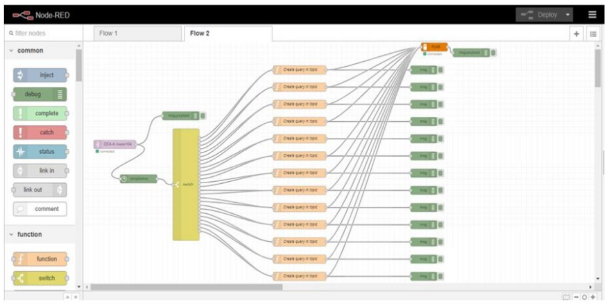


Fig.5. System Flow Through Node-RED

The protocol used in the transport layer, which is the layer that links the user to the network, is Mosquito Broker or MQTT (Message Queuing Telemetry Transport. This is an open-source messaging protocol commonly used for Internet of Things that allows sensors to communicate to the database and publish the data being received [12].

The database is established by creating data tables through phpMyAdmin that handles the administration of MySQL, an open-source relational database management system. The database can be accessed in two different ways. The local server can display a user interface visible as an application though a webhosting server. Users can use or view the application by visiting the website through the browser. User can also view the app when connected to the same network as the server. This is possible through the Localhost Server. The ESP32 also uses the Localhost server to communicate with the database wirelessly.

2.2. Participants

The ten class Beadle were interviewed with regard to their compliance with the said system. The fourteen instructors and the laboratory technician from the department was each given an RFID card for their access of the room. The prototype testing was done with the same department with the total population of 428, instructors and students combined. Sample size was calculated using Raosoft Sample Size Calculator with a confidence level of 95% and a margin of error of 5%. The recommended minimum sample size is 203.

2.3. Data Collection

After the isolation of the test classroom, the watt-hour meter is installed on the main panel to give the reading of its total power consumption. At the end of each day, the submeter was photographed which was the data gathered without the prototype. The reading of the previous day is subtracted from the reading of the actual day. After the installation of the prototype, the submeter was also monitored and photographed and the same procedure was followed to determine the daily power consumption.

After the installation of the system, testing was done and was simulated by students and instructors of the locale. A feedback form was distributed to determine the acceptance of users to the system and what other developments they thought it should possess.

2.4. Data Analysis

T-test was conducted to either reject or accept the Null Hypothesis which states that there is no significant difference in the power consumption of the room if the system is installed or not. Also, the feedback from users will be collated through a form which contains questions whether the user had any difficulty in operating the system and if they would approve of the installation of the system. This would be represented in graphs. Comments and suggestions would also be asked from the end users.

III. RESULTS AND DISCUSSION

The power consumption of the test classroom in a five-day class setup was monitored through a Watt-hour meter with and without the system for one whole week. Results are shown in Tables I and II. This data is gathered by recording the meter after every day to determine the energy consumption each day.

Table.1. Energy Consumption Record of the Test Classroom without the System

Day	Running Hours	Energy Consumption (kWh)
1	9	27
2	10	31.9
3	9	25.8
4	9	25
5	11.5	34.9
Total	48.5	144.6

Hypothetically, the consumed power of the week is just in a repetitive cycle. Therefore, if there is an approximate 4.34524 weeks in a month, total energy consumption without the system can be roughly estimated. Calculating the average power consumption of the room by dividing the total consumption by the number of run-time hours a week results to 2.98 kW per hour. Theoretically, the energy consumed by the room for a whole month is:

48.5 hours x 4.34524 weeks x 2.98 kW = 628.02 kWh

Table.2. Energy Consumption Record of the Test Classroom with the System

Day	Running Hours	Energy Consumption (kWh)
1	9	24.2
2	10	29.7
3	9	24.3
4	9	23.5
5	11.5	31.6
Total	48.5	133.3

Comparing the total consumption of the room with and without the system will yield to a power saving of:

% power savings = (144.6-133.3)/144.6 x 100% = 7.81%

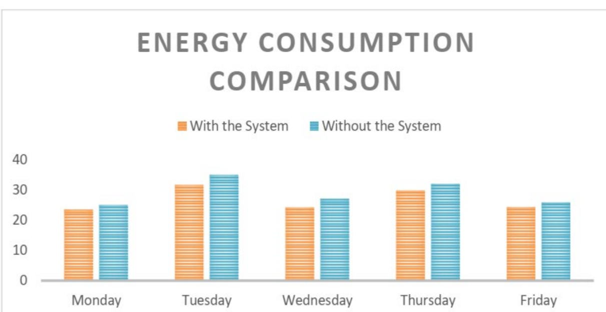


Fig.6. Energy Consumption Comparison

By simply observing the data gathered, the difference is noticeable and shows that having the system lessens the power consumption of the room. Reviewing the database logs when the system was installed a 2 to 20-minute vacant period before the next class starts. On a regular day, without the system, students are usually allowed to enter the room and turn on its power even without an instructor. This is usually the instance that causes power to be wasted. Considering that the test classroom is a well-regulated room wherein it is usually locked and the breaker is manually turned off, there are cases when students will be allowed to go in even without the instructor. 7.81% savings would still be of great value. But more can be done if implemented in a regular room without air conditioning units and that are not well-regulated.

T-test was used to analyze if there would be a significant difference between the power consumption of the room, with and without the system. The researchers used the Data Analysis Toolpak in Microsoft Excel. The results are shown in Table III. From these data, we obtained a p-value of 0.003, which is less than the level of significance which is 0.05. Therefore, we can reject the null hypothesis. This shows that there is a significant difference between the power consumption with and without the system.

Table.3. T-Test: Comparison between the Power Consumption with and without the System

Statistics	Without the System	With the System
Mean	28.92	26.66
Variance	18.36	13.81
Observations	5	5
Pearson Correlation	0.99	
Hypothesized Mean Difference	0	
df	4	
t Stat	6.35	
p-value (two-tail)	0.003	
t Critical (two-tail)	2.78	

From the interview conducted to class monitors regarding the compliance to the beadle system, five out of ten or 50% comply on passing the beadle form every week. Stress on studies, lots of school work and absence of beadle form are some of the reasons why they fail to ask the instructor to sign a beadle form. The monitor needs to be alert, some instructors leave the room immediately after their time. All of them are in favor of the database system that automates the attendance of the instructors. According to them, they said system can save paper. The time in and time out of instructors are more accurate, and to avoid the instances where log out time is forgotten.

For the user acceptance and software evaluation, 207 out of the 207 people asked agreed on the installation of the system in the HEI. Two found it confusing to operate at first. Comments included how greatly significant the system is when it comes to security. Other suggestions were including the students in the attendance system.

An Information Technology Expert was asked to evaluate the system database in accordance with the ISO standard for Software Development which is ISO/IEC 25010 [14] that checks eight qualities of the software which are functional stability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

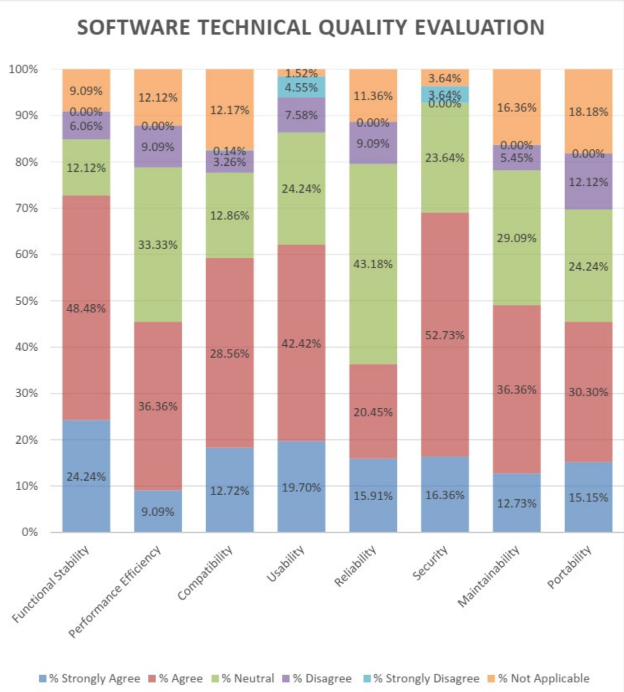


Fig.7. Software Evaluation Results

He agreed that the system possesses these qualities. Ten out of fourteen instructors using the test classroom also evaluated the system website. Results per technical quality whether they Strongly Agree, Agree, Neutral, Disagree or Strongly Disagree from the evaluation is shown in Figure 7.

Majority are in agreement when it comes to the Functional Suitability, Performance Efficiency, Compatibility, Usability, Security, Maintainability and Portability. Reliability of the system needs improvement which got majority of result as Neutral. Purchasing of a webhosting plan would improve the reliability of the system given that it has unlimited capacity and would be provided.

IV. Conclusion

The implementation of a smart classroom using RFID technology shows that there is a significant difference between the power consumption with and without the system, less power consumption is observed with the system installed. 7.81% of power is being wasted. This was observed in the test classroom which is a well-regulated laboratory meaning that its breaker is usually turned off when no class is taking place. Cases involve students who are permitted to stay in the room even without an instructor. Installation of the project on ordinary rooms would make a great impact because these ones are where students by-stand in vacant periods, lavishly spending their electrical energy for nonacademic purposes.

The current Beadle System used by the HEI had been proven to be inaccurate as compared to the database logs of the system with regards to the time in and time out of a certain instructor for a period of time. Students tend to write down their schedules instead of the real login and logout time of instructors. Installation of the said system can help determine which instructor was most punctual and who needs improvement. The database was also proven reliable when it comes to tracking who was the last person in the room when incidents happen.

The system was approved and agreed upon by all 207 participants who would recommend the installation of the system for the HEI. As per the Software Evaluation, the website meets the technical qualities that are required by ISO/IEC 25010.

Another advantage of the project includes the assurance that no appliance will be left turned on which can cause a fire if overheating occurred. The cost of installation of the project would be reasonable enough to protect rooms instead of putting them at stake in case of fire due to overheating.

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