Bantayan Science High School

Ticad, Bantayan, Cebu

IoT-BASED AUTOMATED CLASSROOM DISINFECTION SYSTEM

A Research Project

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ABSTRACT

The research study entitled “IoT-Based Automated Classroom Disinfection System” was conducted to investigate the potential of IoT-Based ACDS as an efficient modern decontamination system. The device was consisted of controller, disinfector and a monitoring app. The device controller and disinfector were fabricated by the researchers using the resources bought from online and local store. The controller and with the other sensors were then programmed using the Arduino IDE which follows the system’s algorithm. The monitoring app which keeps track of the volume of alcohol, stockroom temperature and humidity, and also acts as remote control of the system was then setup through Blynk and Arduino IDE. The device was then installed inside the stockroom wall and ceiling. In the last procedure, the researchers measured the area of the school stockroom and classroom. Afterwards, the IoT-Based ACDS was subjected to test in terms of three technological factors which are effectiveness, software efficiency, and hardware efficiency. In the One-way Analysis of Variance (One –way ANOVA) used in the study for comparing the three trials of IoT-Based ACDS regarding the said factors, it was shown that they do not differ significantly in terms of effectiveness, software efficiency, and hardware efficiency. Thus, IoT-Based ACDS is an efficient modern disinfection system and highly capable in terms of the said properties. It was also concluded that it has various advantages such as effectively decontaminating a wide area coverage depending on the number of nozzles, can daily monitor disinfection processes, room humidity, temperature, and disinfectant volume level.

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To God be the highest glory!

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CHAPTER 1

The Problem and Its Background

Introduction

The Novel Coronavirus Disease 2019 (COVID-19) has affected every nation's economy and it served as an illustration of how important the health of the people has come to be. Particularly in times like this, where COVID-19 has spread globally causing a pandemic, to provide safety for the staff, clients, students, and other individuals on commercial property, extensive care of the facilities must be performed. While the need for disinfection is clear, COVID-19 has highlighted the urgency of using the best precautions to keep people safe. The pandemic has brought far-reaching changes in all aspects of our lives, adjusting in different activities that is propose and, until now, we are still in an adjusting phase of reality. Returning of face-to-face classes, after the lifting of COVID-19 restrictions, exposed students to more school regulations or policies.

In most industries, manual disinfection or cleaning was widely regarded as the most effective method for achieving acceptable standards of cleanliness a few decades ago. However, manual cleaning has a few but significant disadvantages, including long cleaning periods, low and inconsistent cleaning quality, expensive labor and energy costs, and a limitation on the advancement of new procedures and ideas. A clean environment and the safety of the beneficiaries of the facility depend on effective disinfection procedure. Based on one article of Bee Line Inc. (2020), it stated that technology has improved to effectively eliminated COVID-19 on or near positive areas using disinfectant misting.

A cleaning process known as disinfectant misting uses millions of small droplets to completely cover an area and eradicate bacteria and germs. Due to this, a surface can be completely covered, from crack to crevice. After misting, there will be some residual material left behind, but it won’t be overly saturated or wet. The misting device will simultaneously eradicate allergies and odors using particular chemical and hospital-grade disinfectants.

According to Khaled Shaban (2022), evaporative cooling is the foundation of misting technology. By utilizing water vapor, evaporative cooling removes atmospheric heat. Misting technology uses a high-pressure pump to force water through a misting nozzle, resulting in a fog of extremely small water droplet. The most effective way to maintain the proper humidity levels for material and processes is via a misting system.

The Internet of Things (IoT) has automated processes development properties. It is rapidly spreading throughout society and connecting everyone and everything. It develops process and exchange data without human intervention. Where it provides a brighter future for humanity and technology if this is done correctly. IoT technology surrounds all the devices system, hardware, tools, system sensors, and software that connects and support the IoT device through the application development. In this new and improved technology, the IoT advantages, innovations and improves all kinds of applications that have been seen in the mass media. Recently, with all the system that is improving, IoT delivers accurate performance of machines and hardware efficiency to supply chain and enhance logistics operations.

The IoT is being positioned in the healthcare industry to enable real-time remote patient monitoring, robotic surgery, smart inhalation, and more. In actuality, there is plenty of evidence to support the IoT's critical contribution to the COVID-19 pandemic. IoT applications were used to collect crucial data to fight the disease, including connected thermal cameras, contact tracing devices, and health-monitoring wearables. The flawless distribution of delicate COVID-19 vaccinations was made possible using temperature sensors and package tracking. Beyond healthcare, IoT technology is being used. Supply chains that have been disrupted by COVID-19 are becoming more resilient through IoT, and automated labor processes are being used as a strategy to foster social distance in the workplace. IoT is also being used to offer functional systems and industrial devices secure remote access (CP Raj, 2023).

The IoT-Based Automated Classroom Disinfection System is a modern disinfection technology which is an improvement of old technology with new additions and adjustments. By enhancing the workflow, this modern innovation can bring about things much more quickly and effectively. Advanced technology has improved to the point that human interaction is almost unnecessary, which can be achieved by an IoT based device, and it has spread widely that all machinery is being updated even in our daily living. Within the boundaries of all existing automated technology, there is literature advocating for exploring the disinfecting process that form the water particles floating or falling in the atmosphere at or near the surfaces.

The core objective of the study is important for maintaining the cleanliness and for eliminating any hazardous bacteria from the surface up. This disinfection system is specifically designed to reduce the risks of healthcare associated infections. Since it works by emitting millions of tiny droplets of solutions that will disinfect every square inch of the space, harmlessly and efficiently, this research is more than suitable to be implemented so that the manual disinfection operators are safe from the wide-ranging viruses and to offer a safer environment to students as well as school personnel with the invention of IoT-Based Automated Classroom Disinfection System as an efficient modern decontamination system.

Statement of the Problem

This study was conducted to investigate the potential of IoT-Based Automated Classroom Disinfection System as an efficient modern decontamination system. The intention of the study was to install an automatic disinfection system within the classroom setting as an innovative solution to traditional manual disinfection method. Specifically, it answers the following research questions:

1. Is IoT-Based Automated Classroom Disinfection System an efficient modern decontamination system?
2. How capable is IoT-Based Automated Classroom Disinfection System to be an efficient modern decontamination system in terms of:

   a. effectiveness;

   b. software efficiency; and

   c. hardware efficiency?
3. What are the pros and cons of having IoT-Based Automated Classroom Disinfection System in a classroom setting?

Research Hypothesis

1. **Effectiveness**

   H_o: There is no significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of effectiveness.

   H_a: There is a significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of effectiveness.

2. **Software Efficiency**

   H_o: There is no significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of software efficiency.

   H_a: There is a significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of software efficiency.

3. **Hardware Efficiency**

   H_o: There is no significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of hardware efficiency.

   H_a: There is a significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of hardware efficiency.

Theoretical/ Conceptual Framework

Software

Software is a set of instructions, information, or computer programs that are used to run devices and perform certain tasks. It is the opposite of hardware, which refers to a computer's outward parts. A device's running programs, scripts, and applications are collectively referred to as "software" in this context (Linda Rosencrance, 2021).

According to Jared King of Saylor Academy (2021), the term "software" was first used in print by John W. Tukey in 1958. The term is frequently used in casual contexts to refer to application software. All information processed by computer systems, programs, and data is referred to as "software" in computer science and software engineering. Computer science and software engineering are the academic subjects where software is studied. Writing software has developed since its inception in the 1940s into a profession concerned with how to best maximize the quality of software and of how to build it. Quality can relate to a variety of characteristics, including how easily maintainable software is, as well as its speed, usability, testability, readability, size, cost, security, and amount of faults or "bugs". It can also refer to less quantifiable traits, such as elegance, succinctness, and customer pleasure, among many other characteristics. Software design principles, so-called "best practices" for coding, as well as more general management issues like the ideal team size, process, how to deliver software on time and as quickly as possible, workplace "culture," hiring procedures, and so on are all part of the debate over how to best create high quality software. These are all included in the wide category of software engineering.

Hardware

Hardware, sometimes known as HW, is any tangible part of a computer system that includes circuit board, integrated circuits, or other electronics. The screen on which you are seeing this website is a perfect example of hardware. It is hardware, whether it be a monitor, tablet, or smartphone (Computer Hope, 2021).

Beginning in 1960, solid-state devices like the transistor and then the integrated circuit replaced vacuum tubes, marking a turning point in the development of computing technology. By 1959, it was thought that discrete transistors were dependable and cost-effective enough to render future vacuum tube computers uncompetitive. Solid-state static and dynamic semiconductor memory gradually replaced magnetic core memory devices as the primary storage medium for computers, resulting in significant reductions in their cost, size, and power consumption (Saylor.org, 2021).

Ethanol/ Ethyl Alcohol

Based on 2021 research study of S. Das, M.K. Meinel, Z. Wu and F.M. Plathe, the researchers proposed a study regarding the virus effects of ethanol alcohol, which was experimented and proved that is considered one of the essential disinfectant sprays in exterminating viruses. The protective envelope that covers enveloped viruses can be destroyed by ethanol, which makes it very effective against them. The interactions between the corona virus envelope (E) protein— a small and integral membrane protein, and its membrane environment are critical to the viral envelope's stability and function. The mentioned researchers investigated the underlying mechanism of ethanol-induced membrane disruption in a model coronavirus and the interactions of the E-protein and lipids in detail using molecular dynamics simulation. Together with the coronavirus E-protein, palmitoyl sphingomyelin and 1-palmitoyl-2-oleoyl phosphatidylcholine lipids make up the membrane bilayer. According to the findings, ethanol causes an increase in the lateral area of the bilayer, as well as bilayer membrane thinning and lipid tail orientational disordering. Ethanol is found in the membrane's head-tail region and increases bilayer permeability. The study discovered an increase in lipid tail ordering caused by envelope proteins. Their simulations also shed light on the orientation of the envelope protein in a simulated membrane environment. They saw disintegration of the lipid bilayer and dislocation of the E-protein from the membrane environment at % ethanol in the surrounding ethanol water phase.

Paradigm of the Study

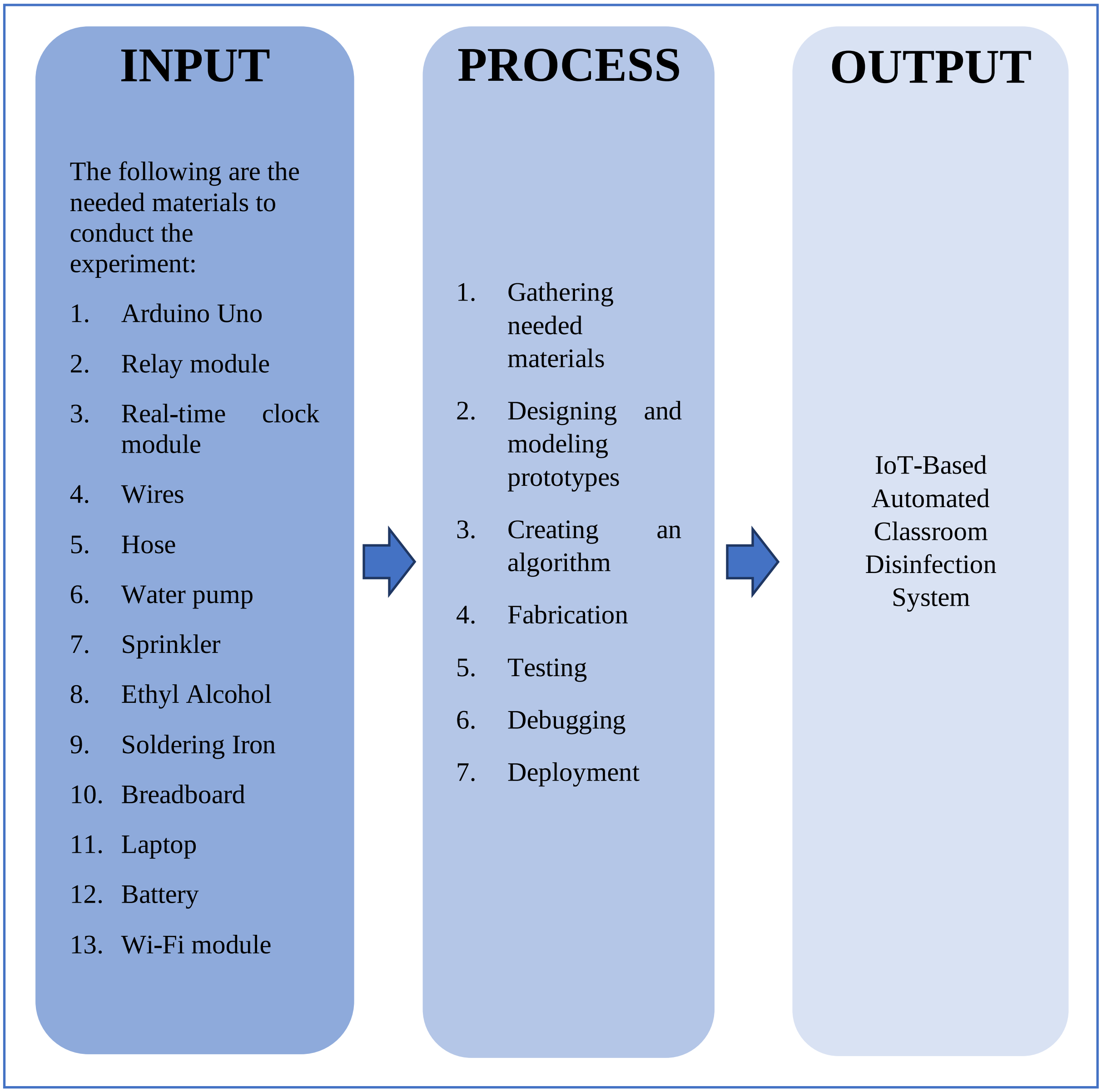


Figure 1. Input-Process-Output Model of IoT-Based Automated Classroom Disinfection System

The researchers first gathered the materials that were needed in conducting the research experiment. The materials that were stated above were used to design and model the prototypes of IoT-Based Automated Classroom Disinfection System. After generating the prototypes, researchers created an algorithm to avoid mistakes in conducting the study. Testing and debugging were also done to discern how practical the quality, performance or reliability of ACD is. The IoT-Based ACDS was ready-to-use and was expected to function properly. Upon subsequent to the process, the researchers converged the target output of IoT-Based ACDS.

Scope and Delimitations of the Study

The general intent of this study was to create an automatic and efficient way of disinfecting classroom settings. This study was limited only in determining the potential of IoT-Based Automated Classroom Disinfector (ACD) as an efficient modern decontamination system The purpose of this research was to provide easier way to disinfect classrooms especially in this time of pandemic. It also yearns for the researchers to understand, develop, and help students, teachers and school staff.

The IoT-Based ACDS was intended only at school campus. Wherein, it refers that the said study provides a less hassle work for manual disinfection operators in terms of disinfecting classrooms. The study was also proposed to help the school in keeping a better and safer environment for students to learn and teachers to teach amidst the COVID-19 pandemic. Thus, maintaining school cleanliness which can result to improved students' school performance and teachers' job satisfaction.

Significance of the Study

Through this advanced disinfection technology, the study was expected to lower the virus exposure risk of manual disinfection laborers and also reducing their workload in disinfecting classroom setting. One benefit of the outbreak was the hastened technical advancements in room decontamination and cleaning. Manual disinfection operators, students, teachers, school staffs and the community, all recognized the need of protecting everyone's safety and health. Henceforth, the advantageous will gain to these beneficiaries:

Manual disinfection operators

As manual disinfection workers disinfect different establishments to keep surfaces clean and free from bacteria, they are still in high risks of being infected by viruses even with proper suits and equipment. Thus, this study was conducted to keep manual disinfection laborers from virus infection. Additionally, the study also benefits them by reducing their work in disinfecting procedure, while ensuring their safety when they are exposed in hazardous areas.

Students

One of the goals of the study was to help students ensure that their classrooms are properly disinfected for their safety. The efficacy of IoT-Based ACDS can increase immunity to viruses and bacteria. This technology, which was installed in the classrooms of Bantayan Science High School can assist to help keep the classroom daily sanitized, considering that schools were already decided to open their personal classes in the midst of the COVID-19 pandemic. Through this disinfection innovation, this system will ensure daily cleanliness and thorough disinfection in the classroom settings.

Teachers

Teachers can also benefit from this technological advancement through sanitation and thorough disinfection of classrooms. They can benefit with this study health wise, and improve the cleaning and sanitation of the rooms. This addition of technology to school establishments assists the safeguard and protection of the teaching personnel in the classroom from virus infection. Thus, results of this study can be important for safety of teachers while teaching inside the classrooms.

School staff

The school staffs can ensure their safety against bacterial spreading. When classrooms are thoroughly disinfected and sanitized, lower risk of virus transmission in school is expected. Thus, benefiting not only students and teachers, but also other school staffs.

Community

The community will benefit from this study due to its safety and simplicity. It is a useful system for a community. A community can benefit in this technology advancement in ensuring that manual laborers, students, teachers and school staffs coming home is safe against virus and bacterial infection. The community can ensure that there is low risk of spreading a virus from people who goes and go out of the school.

Future researchers

For future researchers, they can benefit from this study through making this research study a guide or a reference for their own study. They can make improvements by either following the recommendations or making a new system but with the same idea and concept. Future researchers also have an easy start for their study while also modifying our study for a better output.

Definition of Terms

The following terms are defined based on how they are used operationally and/or conceptually in the study. The terms defined below mainly reflect the important terms used in the research design and methodology that are crucially meant to be unequivocal for the replicability of the study.

Algorithm – operationally defined as a precise list of instructions that, in either hardware-based or software-based routines, carry out predetermined operations step by step.

Arduino board - a platform for open-source electronics that uses user-friendly hardware and software.

Automated - to have a factory or office operation run by computers or machines in order to decrease the quantity of work done by humans and the time it takes to complete the task.

Breadboard - a thin plastic board used to house wired-together electronic parts, such as transistors, resistors, chips, etc.

Debugging – operational, refers to a multi-step procedure that entail detecting a problem, locating its cause, and either fixing the issue directly or finding a means to get around it.

Decontamination – is a combination of processes that removes or destroys contamination so that infectious agents or other contaminants cannot reach a susceptible site in sufficient quantities to initiate infection, or other harmful response.

Deployment – operationally defined as the transition of a product from a temporary or development state to a desirable or permanent state.

Ethyl Alcohol – operational, refers to a disinfectant agent that is utilized as an antimicrobial effect that kills microorganisms by causing their cell walls to dissolve and their proteins to become denaturized.

Fabrication – operationally defined as the process of building things by integrating pieces that are normally standard utilizing one or more separate processes.

Hardware - refers to the external and internal devices and equipment that enable you to perform major functions such as input, output, storage, communication, processing, and more.

Internet of Things (IoT) – operational, refers to a network of physical items, or “things” that are equipped with sensors, software, and other technologies in order to communicate and exchange data with other systems and devices over the Internet.

Real-time clock module - a battery-powered clock that is included in a microchip in a computer motherboard.

Relay module - an electrical switch that uses an electromagnet for operation.

Software - is a set of instructions, data or programs used to operate computers and execute specific tasks.

Soldering iron - a tool used for melting solder and applying it to metals that are to be joined.

System software - is a type of computer program that is designed to run a computer's hardware and application programs.

CHAPTER 2

Review of Related Literature and Studies

IoT

The Internet of Things, or IoT, is the collective term for the network of interconnected devices as well as the technology that enables them to exchange data with one another and the cloud. IoT nodes, which are composed of a single-board computer and camera, are proposed as a conceptual system for monitoring and coordinating indoor disinfection processes. These nodes separate the human density in various areas into varying levels using image processing techniques, and then store these densities in a cloud database. An Android software locates the dangerous regions on the map by periodically reading data from a cloud database. When the sterilization crew disinfects the designated regions, the database is updated to reflect that disinfection is complete in those locations after the sterilization personnel's location is established in the Android application through nearby Bluetooth beacons (Aydemir F., 2020).

In addition, Abro et al. (2021) proposed a smart disinfection entrance gate based on UV irradiation and sanitizer spray stations. This cutting-edge, embedded system design-focused gate will first take the entrant's picture, then measure the temperature, then spray sanitizers, and finally provide ultraviolet radiation to ensure that the entrant has fewer chances of carrying the coronavirus. The study demonstrates the capability of IoT features that aid in keeping data records of suspectable, exposed, infected, and recovered individuals, which will later aid in lowering the COVID-19 reproductive co-efficient Ro in any state of Malaysia.

Misting System

R. Soriano (2018) of the Asia Pacific Journal of Multidisciplinary Research published an article about the functions of Automated Misting Systems. The article states that the user must specify the humidity range that the system should maintain. The system will check on the humidity sensor's condition and compare its readings to a preset value. When the obtained humidity falls below the minimum set humidity range, the system automatically activates (sprays mist) to maintain the user-set humidity range. The system will automatically shut off once the selected maximum range of humidity is reached. In addition, the system can also monitor the status and contrast its information with the user's preset value. The misting system will activate automatically if the temperature exceeds the user-set threshold. But as soon as the temperature drops to the user-selected safe level, the device will immediately stop the misting process.

In the planning phase of methods, the researcher performs the preliminary investigation to identify the nature and the study's range. The researcher carries out a feasibility analysis of the practical, technical, schedule, and economic requirements of the study. Moreover, the researcher conducts the review of numerous associated publications and studies that would aid the researcher to identify the strengths and the opportunities that will help the proposed study's design. During the analysis phase, the researcher designs the logical model of the system. The researcher determines the functional and non-functional requirements of the system to determine what the system must do. Fact-finding will be done during this phase where the data and process model will be based. The researcher during the system design phase creates the essential diagrams that will help represent the study to the target users as well as readers. The researcher also designs the user interfaces of the system to help identify the required input, process, and output of the program. The system is coded using PHP and Python and tested to check for program errors. The system is continually developed until the necessary requirements have been achieved. During the implementation phase, the researcher tested the system and have the intended user test the system to gather some recommendations and suggestions from them. This will continually take place until the client is satisfied. When the system satisfies the client's needs, the system is then made available for the user (Soriano, 2018).

A person is exposed to mist for 20-30 seconds using the recommended disinfectant, usually diluted household bleach. Although these are currently used as methods to minimize the spread of the virus and avoid cross-infection inside workplaces, a rapid review (April 2020) found no evidence regarding the efficacy of these measures for COVID-19 prevention and control. The effectiveness of these cleaning chemicals was only evaluated when they were used to clean surfaces, not as misting or spraying agents. There is no proof that spraying can stop an infection, the capacity of one person to infect another. The mist can also irritate the nasal passage and producing an infected individual to sneeze and potentially spread the virus. The mucosal lining of the respiratory system, exposed skin, and the eye may all become infiltrated by the aerosolized particles. Common signs and symptoms include skin, respiratory tract, nose, and eye irritation. The risks can be further amplified by exposure that is repeated and lasts longer (Eubanas, G. MD, FPDS, GDip (ClinEpi) et al., 2021).

Modern Technology Disinfection

The main issue with conventional ultrasonic and infrared-based dispensers is that they frequently malfunction when used in crowded public spaces owing to interference from sunshine, car sound, etc. The automated touchless hand sanitizer dispenser proposed a laser-based detecting device to distribute sanitizer automatically in order to get over these restrictions. The LDR-based automated hand sanitizer dispenser system is a revolutionary idea, and it is more affordable than traditional ones, according to the automated dispenser's following novel design. Design and subsequent fabrication of a low-cost, touchless, automated sanitizer dispenser to be used in public places such as healthcare facilities, schools, shopping malls, etc.

It was determined that the manufactured device was more effective and cost-effective than other dispensers on the market after analyzing its overall performance in terms of cost, power consumption, and environmental factors while using it in crowded public spaces and indoor environments in Bangladesh's largest cities. The disclosed gadget is anticipated to play a significant part in contactless hand sanitization in public settings and stop the transmission of infectious diseases in the general population (Das, n.d. *et.al*., 2021).

J.M. Boyce (2016) of Antimicrobe Resist Infect Control 5 published modern technologies for improving cleaning and disinfection of environmental surfaces in hospitals based. Some of the most current "no-touch" (automatic) decontamination methods include aerosol and vaporized hydrogen peroxide, portable devices that produce continuous ultraviolet (UV-C) light, a pulsed-xenon UV light system, and the utilization of high-intensity narrow-spectrum (405 nm) light. In addition to conventional cleaning and disinfection techniques, it's likely that more people will use more recent liquid disinfectants and certain no-touch room decontamination devices.

Moreover, Kaicheng R., et al. (2021) of the Department of Electromechanical Engineering at the University of Macau published a paper based on an autonomous indoor disinfection robot for combating bacteria and viruses. The design and development of a revolutionary, cost-efficient autonomous disinfection robot system for wide-ranging disinfection applications is the core contribution of this article. In this work, an autonomous indoor disinfection robot has been built for indoor auto-disinfection by combining the aforementioned strategies.

A variety of indoor conditions have been used to test the created disinfection robot. Due to the lack of a COVID-19 virus sample, bacteria were employed as the effect indicator of disinfection rather than the virus to evaluate the disinfection effect. According to the results of the disinfection test, the created disinfection robot exhibits great effectiveness in battling the COVID-19 pandemic.

Hospital-acquired infections (HAIs) continue to be a major issue, which shows that the usual cleaning methods are insufficient. In 10 hospital rooms, 50 surfaces were decontaminated using a no-touch automated disinfection (NTD) system, and its efficacy was evaluated. An ATP bioluminescence assay and a microbiological assay were used to evaluate the contamination of surfaces. The study showed that NTD is a feasible method of decontamination: when added to standard decontamination procedures, it can further decrease the risk of HAIs. It seems that ATP bioluminescence assays with standard cut-offs are not valid for assessing the effectiveness of NTD (Tarka & Osuch, 2020).

In order to lower the risk of SARS-CoV-2 transmission in healthcare and educational environments, the researchers examine the advantages and disadvantages of using disinfection robots. The researchers emphasize that more work needs to be done to determine and improve the effectiveness of these robots in inactivating the virus, despite the fact that there is some potential for using robots to assist with manual cleaning (Cresswell & Sheikh, 2020).

Manasa (2022) of EAI Endorsed Transactions published an article about UV Disinfection Robot with Automatic Switching on Human Detection. The article stated that ultraviolet (UV) light is utilized for the purpose of disinfection or sterilization of rooms and surfaces. UV-C is used because it possesses germicidal qualities, in particular - bacteria and viruses but it is hazardous to human beings as well. UV Robot adheres to a predetermined course that has been constructed and put into use for the purpose of disinfection without human intervention. PIR sensor and an embedded Arduino system are used, to detect human or animal presence. Consequently, one of the most effective ways to prevent contracting SARS-COV-2 (Corona Virus) is by sterilizing rooms using UV Robot. The robot will be able to roam around the space and on identifying humans or animals with the help of IR motion, it turns off the UV light, automatically making it safer and feasible to operate everywhere and from anywhere by scheduling the period of disinfection.

Triggiano et al. (2022) of No-Touch Automated Disinfection System Based on Hydrogen Peroxide and Ethyl Alcohol Aerosols for Use in Healthcare Environments published an article on the effectiveness of a no-touch disinfection system that sprays 5% hydrogen peroxide and 10% ethyl alcohol was examined in this study. To assess the efficiency of the aerosolization system, the total bacterial and total fungal counts in the air and on the surface of the room were determined after choosing an environment. The system's effectiveness against bacteria and fungus on stainlesssteel plates and in the air was demonstrated by the results. According to the study, the AHS is more efficient than CHS devices at promoting complete hand sanitation. In order to promote thorough hand hygiene practices, it is advised that the AHS be used.

Canlas et al. (2014) discussed about the Effectiveness of the Automated Hand Sanitation Unit (AHS) and Conventional Hand Sanitation Devices. It states that everyone prioritizes washing their hands when it comes to maintaining good hand hygiene. Additionally, the effectiveness of automated hand sanitization (AHS) and conventional hand sanitization (CHS) hand washing equipment was compared in this study. Selected respondents examined and rated the AHS and CHS devices according to the FURPS Quality Model's criteria for functionality, usability, dependability, performance, and supportability. The study comes to the conclusion that the AHS is more successful than CHS devices at promoting thorough hand sanitation. Therefore, it is advised that the AHS be used to promote thorough hand hygiene practices.

Arduino

Electrical projects are developed using the open-source Arduino platform. With Arduino, you can use IDE (Integrated Development Environment), a computer application, to create and upload computer code to a physical programmable circuit board (often known as a microcontroller). Everything needed to support the microcontroller is included; to get started, just use a USB cable to connect it to a computer, or an AC-to-DC adapter or battery to power it (Makerlab, 2020).

According to Budiharto (2020), many different methods of robot control have been proposed by scientists. Obstacle avoidance can be self-driven or accomplished using Bluetooth. The authors have previously conducted research on Bluetooth technology and ultrasonic sensors for robot control. The researchers employ a DC motor and robot drivers with a high voltage of 24V and a current of 7A move powerfully enough. To accept commands, the Bluetooth module will be utilized. from App Inventor and HP for Android. A relay is utilized to turn on the 12-volt pump spray. To operate the microcontroller, we created a program. utilizing Arduino. The authors created Android apps for remote control using App Inventor. Bluetooth technology has a very strong security system. It should be first clicked the Click the connect button on apps, then select the robot's Bluetooth device identifier. The researchers utilize App Inventor features like touch down and touch up, making navigation of the robot simpler. According to the trial, using a pump to spray a disinfectant is sufficient. up to 2.5 meters. The robot is also able to spray and avoid obstacles in front of it thanks to its three distance sensors.

The device's primary function is to rid surfaces of any dangerous bacteria or pathogens. It is vital to remove these organisms because of the high rate of transmission they have through the medium of air on any surface. Arduino is a free and open-source tool for the platform. The Arduino IDE will be used to run the program. It is possible to write computer code and then run that code. Publish it on a real board. Arduino's board is a board that can be used by delivering a set of using integrated Arduino to transmit commands to the microcontroller it contains an environment for development (IDE). To be able to write the researchers utilized embedded C to write the Arduino code. The researchers created a disinfection box in Embedded C and manage how it functions. The tray is unlocked using a sensor. When a hand is placed in front of the sensor, it detects the tray opens with a slight movement. The thing in that tray that has to be cleaned. the location an object is cleaned from one side before usage of the servomotor, the item is inverted presently, cleaning is being done from the opposite side likewise. A suitable timer has been set. As the UV light is finished, the tray opens so that the completely positioned object should be collected, currently cleaned.

All foreign and local related literature stated above contribute greatly in unifying and strengthening the foundation knowledge of the researchers about the research topic. They are truly crucial in providing basic and complex concepts as the researchers comprehend and conduct the procedure of the study. Information about disinfectants, modern technology disinfection, uses of

Arduino, IoT, and misting system are included because they serve as an overview of insights about the topic. Thus, helps the researchers understand better the current study and create framework on which to build an appropriate hypothesis.

CHAPTER III

Research Methodology

This research study was conducted to investigate the potential of IoT-Based Automated Classroom Disinfection System as an efficient modern decontamination system inside a classroom. To come up with scientifically valid results, the researchers enlisted the materials and procedures necessary for data collection.

Research Instruments

Quantity	Unit	Materials/ Equipment
1	Piece	Arduino Uno
1	Gallon	Ethyl Alcohol
1	Piece	Acrylic Case
2	Pieces	Bent Joint
1	Piece	Buzzer
1	Piece	Computer
120	Pieces	Jumper Wire
1	Piece	Liquid Container
12	Pieces	Misting Nozzle
12	Pieces	Misting Nozzle Tee Connector
1	Piece	Plywood
1	Piece	Pliers
1	Piece	Quick Connector with Thread
1	Piece	5v Relay Module
1	Piece	Soldering Iron
4	Pieces	Screwdrivers

1	Piece	Teflon Tape
1	Piece	120PSI Water Pump
1	Liter	Water
1	Piece	Ultrasonic sensor
1	Piece	12V AC/DC Power Supply
10	Meters	4/7 mm Hose
2	Pieces	4 mm Barb Tee Connector
2	Pieces	4mm Plug
1	Piece	Breadboard
1	Piece	USB Cable A to B
1	Piece	ESP01s Wi-Fi module
1	Piece	Pneumatic Fittings Connector
1	Piece	Smartphone

Table 1. List of Research Materials

The ATmega328P (datasheet) is the basis for the Arduino Uno microcontroller board. It has a 16 MHz ceramic resonator (CSTCE16M0V53-R0), 6 analog inputs, 14 digital input/output pins, a USB port, a power jack, an ICSP header, and a reset button. Everything that one needs to support the microcontroller is included; all one need to do to get started is connect it to a computer through USB, an AC-to-DC adapter, or a battery (Makerlab, 2023). This will serve as the system's brain.

A computer is a device that can be configured to carry out logical or mathematical processes in sequences automatically. Modern computers can execute generalized sets of operations known as programs. These apps allow computers to do a wide range of jobs. (Wikipedia, 2020). A computer is used for input and programming the system.

A relay module is a switch that is powered by electricity. It is made up of an input terminal for a single or more control signals and an operating contact terminal. The switch may have an unlimited number of contacts in various contact forms, such as make contacts, break contacts, or a mix of the two (Makerlab, 2023). It acts as the switch for the water pump to function.

A misting kit was installed as part of the project to serve as a whole-body disinfection of a classroom. (Shopee, 2023). The misting pump is an essential material in the research, because it allows the disinfectants to be sprayed in a classroom.

A water pump works by transforming rotary energy into kinetic energy and then into pressure energy. This is done by first drawing water into the pump's intake, where the impeller's rotation drives the water through the diffuser. It then rises to the surface (Makerlab, 2023). The water pumps help in pumping disinfectants throughout the ACD system to be sprayed in the classroom.

A buzzer, often known as a beeper, is an aural signaling device that can be mechanical or electronic. Alarm devices, timers, and confirmation of human input are common applications for buzzers and beepers (Makerlab, 2023). This is used in the study like an alarm that goes off when it is the time that the researchers set for the system to do its disinfecting and it is also used to notify the owner that the disinfectant is low or empty.

The DHT22 Temperature and Humidity Sensor is a basic digital temperature and humidity sensor that is inexpensive. It gives a digital signal on the data pin after measuring the surrounding air with a capacitive humidity sensor and a thermistor. It is quite straightforward to operate, but data collection requires precise timing. The only major disadvantage of this sensor is that you can only collect new data from it once every 2 seconds, so sensor values can be up to 2 seconds outdated when using our library (Makerlab, 2023). The DHT22 was used in determining the stockroom temperature and humidity.

The ultrasonic sensor HC-SR04 determines distance to an object using sonar. It provides outstanding non-contact range detection in an easy-to-use design, with high accuracy and reliable results. From 2cm (about 0.79 in) to 400cm (1" to 13 ft). Its operation is unaffected by sunlight or black materials, as Sharp rangefinders are (but acoustically soft materials such as fabric can be difficult to detect) (Makerlab, 2023). The ultrasonic sensor was used in determining the volume level of disinfectant in a container.

The ESP8266 WiFi Module is a standalone SOC with a built-in TCP/IP protocol stack that can give any microcontroller access to your WiFi network. According to Makerlab (2023), the ESP8266 can host apps or delegate all Wi-Fi networking responsibilities to another application processor. The Wi-Fi module was used for the connection between the ACDS, ACDS app and Blynk.

Research Environment

The researchers conducted the procedure of the study at Bantayan Science High School Science Laboratory such as the preparation of materials, fabrication of the device, programming, setting up the buzzers, water pump, alcohol level sensor, testing, and debugging. The technological tests were done at the Bantayan Science High School Campus.

Research Design

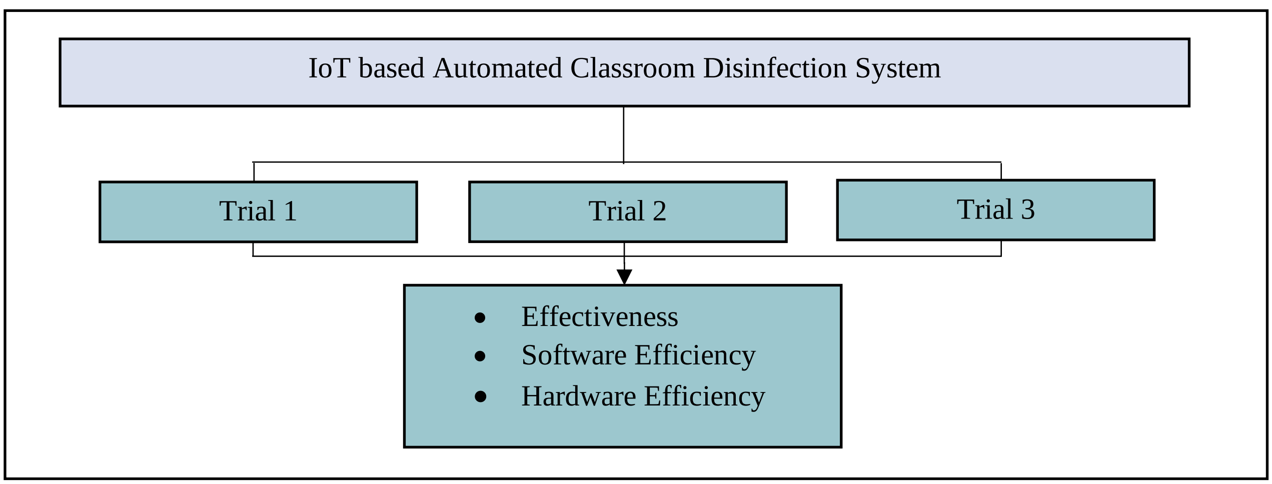


Figure 2. The Research Design of the Study

The researchers' used one-shot case study research design since there was no control group in the study, any changes were believed to have been brought on by the event. The researchers were able to objectively test their hypothesis due to this research design. They conducted three trials to make sure that the findings are fair and uninfluenced by the design. The method of data collecting was through the ratings of the researchers' panel of raters.

Research Procedure

Phase I. Preparation of Making the Automated Classroom Disinfector (ACD)

A. Preparation of Materials

The materials were bought on Makerlab Electronics, and online shop. The system used an Arduino Uno Board. The other materials that were purchased online were 9V AC/DC power supply, acrylic case, misting system kit, relay module, real-time clock module, water pump, water level sensor, jumper wires and buzzer. The other materials that were not stated were bought on any local store within Bantayan.

B. Fabrication of the Device

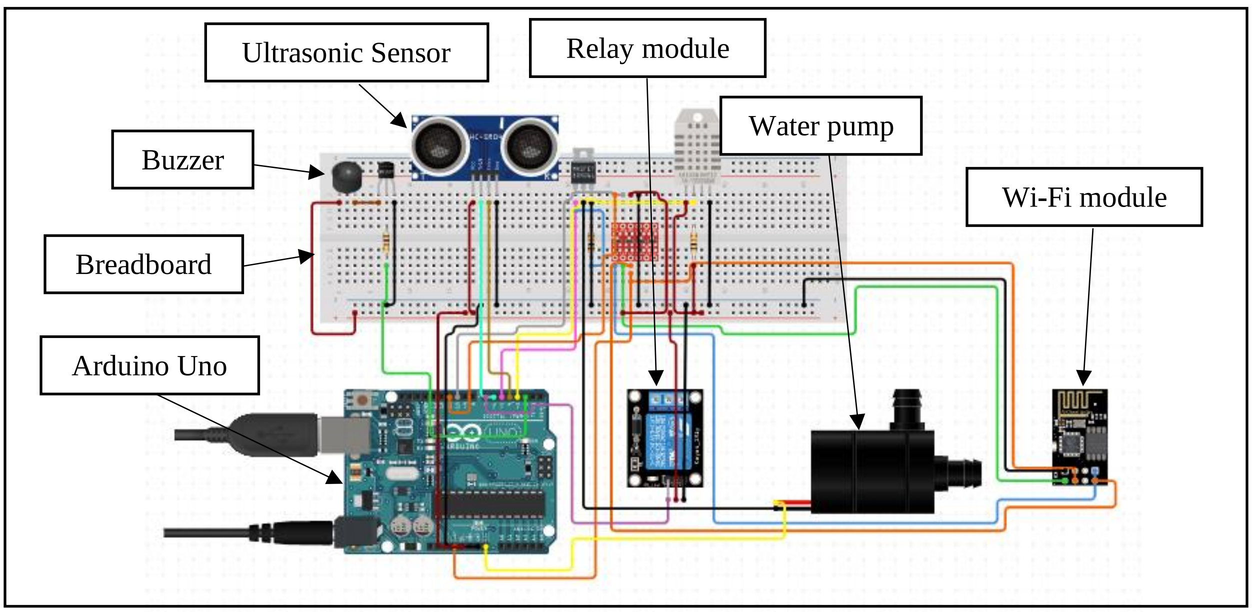


Figure 3. Schematic Design of IoT-Based Automated Classroom Disinfection System

The controller was composed of Arduino and other sensors. The controller was made of plywood to protect the Arduino and other sensors from damaging. The controller size measures 12 inches wide and 15 inches in length. It was handcrafted by the researchers by using a hammer, 1-inch nails, plywood and a wood glue. After it was formed by following the desired dimension, it was then brought to the Sandra glass shop to attached the glass pane in front to act as a door. The inside portion of Arduino box was painted using a white paint and varnish in the outside. It was also drilled at the bottom center of the controller to make way for the wirings. Lastly, the Arduino Uno, breadboard, and other sensors were put in place inside the controller box.

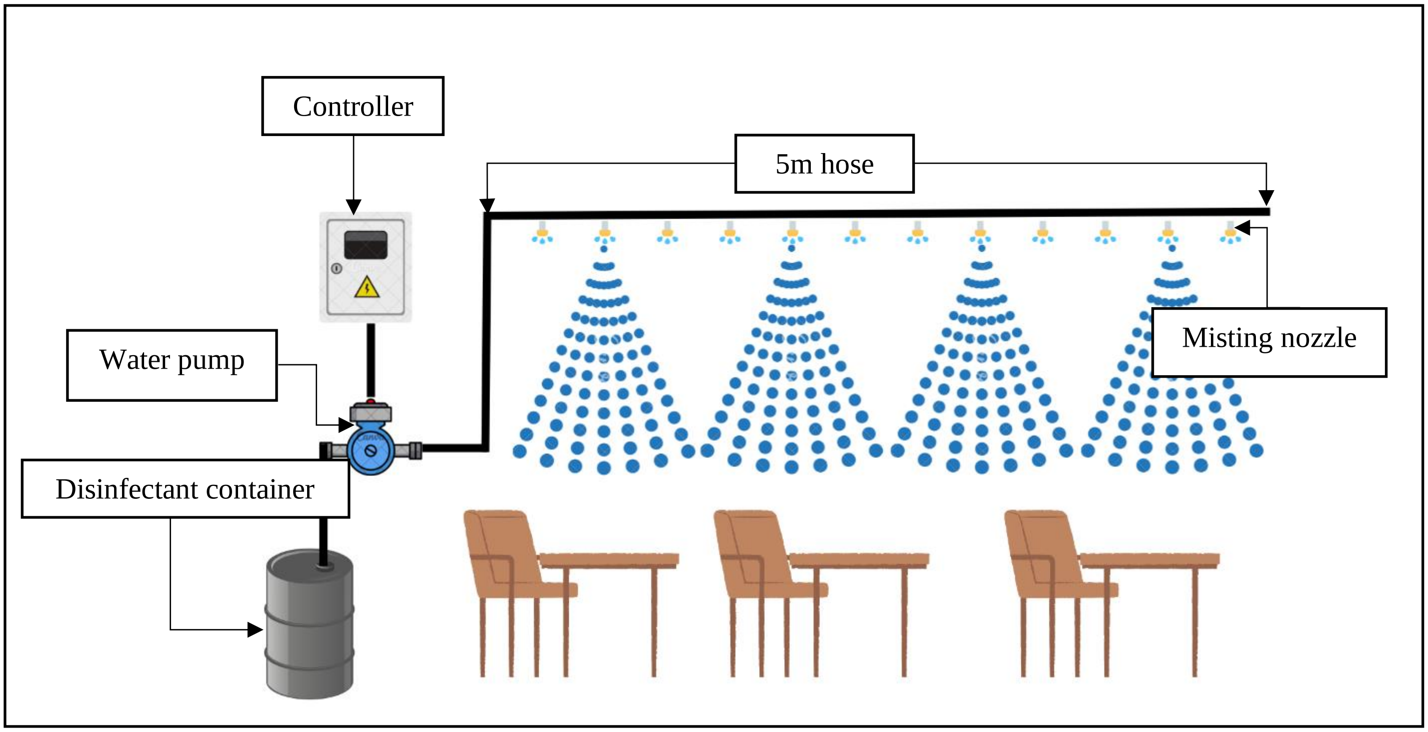


Figure 4. Side view of the IoT-Based Automated Classroom Disinfection System

The system was then installed inside the stockroom wall and ceiling. The controller was placed using a bracket and a metal brace while the water pump was placed by drilling a hole in the wall to screw the water pump below the controller. The hose and misting nozzle were lay using a cable clip or PVC clamp in the wall and ceiling. The misting kit was installed in the ceiling so that it has wider coverage of the area. The disinfectant container was an old water container that was drilled and melted at the top to make way for ultrasonic sensor and it was placed below the controller and water pump.

C. Programming

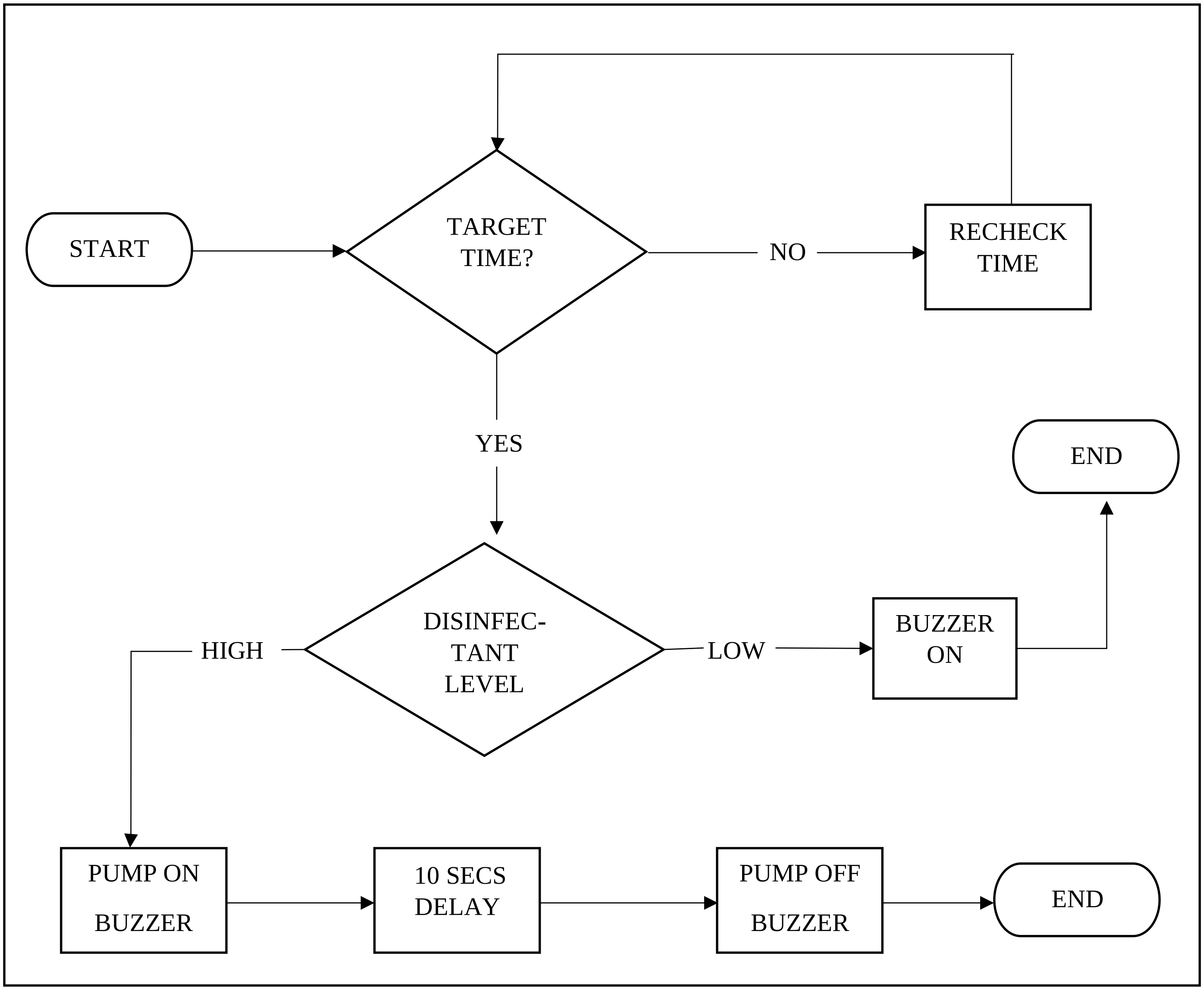


Figure 5. System Flowchart of IoT-Based Automated Classroom Disinfection System

The entire system was programmed using the researchers' personal computer and connected to it. The researchers programmed an algorithm that was suited for the system's functions. Then, the researchers compiled the code using the Arduino IDE into the Arduino Board.

D. Setting up the Blynk Server Time, Relay Module, and Water Pump

The system time was set using the Blynk server time. The system was assumed to start at default time wherein the students have no classes already or at the specific time in which the owner set the target time on the Blynk ACDS app. The water pump started pumping the disinfectant solution into the misting nozzle and start disinfecting the classroom.

E. Setting up the Buzzer and Ultrasonic Sensor

The ultrasonic sensor monitored the volume level of disinfectant solution inside the disinfectant container. If the disinfectant solution is already low, it sends an alarm using a buzzer and a notification through the app, and automatically alert to stop the system and to prevent the device from damaging. The system then checks the volume of disinfectant if it is sufficient to disinfect the classroom and is determined by the ultrasonic sensor.

F. Setting up the Temperature and Humidity Sensor

The DHT22 sensor monitored the stockroom temperature and humidity for every 500 milliseconds. For every 500 milliseconds, it sends the data to the Blynk server and then the IoT-Based ACDS app request those data and display it in the app.

G. Setting up the Wi-Fi module and Blynk ACDS app

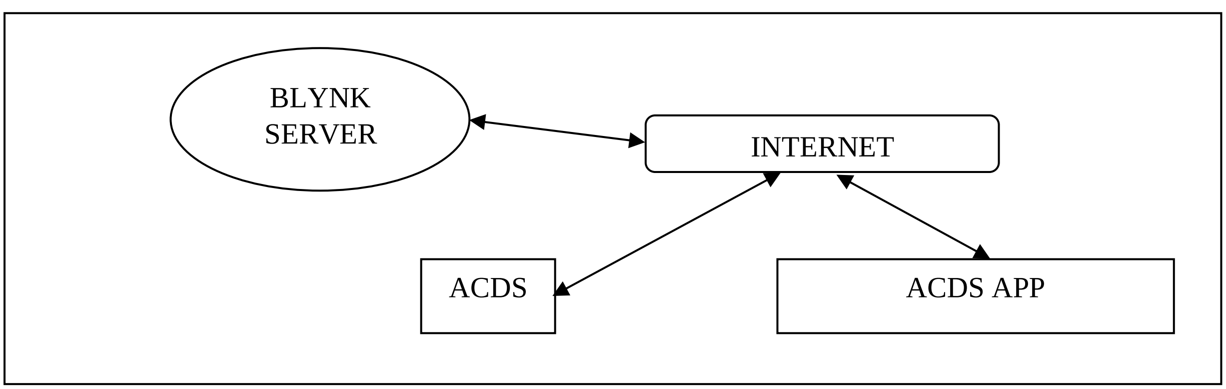


Figure 6. Network Diagram of IoT-Based Automated Classroom Disinfection System with IoT-Based ACDS app and Blynk Server

The Wi-Fi module acted as a wireless connection from IoT-Based ACDS to the IoT-Based ACDS monitoring app. The data was sent directly to the Blynk server through a private Wi-Fi connected to the internet. The IoT-Based ACDS app then request the data from Blynk server to display it in the app. Wherein, the owner can remotely monitor and control the IoT-Based ACDS.

H. Testing and Debugging

The IoT-Based ACDS was tested multiple times to determine any errors and problems. The researchers encountered some technical errors then they immediately fixed the problem, and it undergone another testing until the device was ready and cleared of errors.

I. Measuring the Area of the Stockroom and Classroom

In the last research procedure, the researchers measured the area of the school stockroom and classroom to identify the number of nozzles needed per area coverage by comparing the area of the stockroom and typical classroom setting. The researchers then made a ratio of the number of nozzles that were used in the area of stockroom equivalent to the assumed number of nozzles that were expected to use in the area of a classroom setting.

Phase II. Tests for Technological Properties

A. Effectiveness

In determining the effectiveness of the IoT-Based Automated Classroom Disinfection System, a panelist consisting of 3 chosen teachers was asked to rate both sheets in terms of the said property.

B. Software Efficiency

For the software efficiency property, the same panelist was asked to rate the IoT-Based Automated Classroom Disinfection System.

C. Hardware Efficiency

For the hardware efficiency property, also the same panelist was asked to rate the IoT-Based Automated Classroom Disinfection System.

Statistical Parameter

The capability of the IoT-Based Automated Classroom Disinfection System as an efficient modern decontamination system was tested using One-way Analysis of Variance (One-way ANOVA). The effectiveness, software efficiency, and hardware efficiency are rated and determined by a panel of raters.

Factor 1: Effectiveness

Effectiveness refers to the area coverage and misting capability of IoT-Based Automated Classroom Disinfection System. It ensures if IoT-Based ACDS is misting effectively or not. The panel of raters rated the effectiveness of IoT-Based ACDS trial 1, trial 2, and trial 3 following the rating scale below:

1 – Not at all Effective (can't mist at all)

2 – Slightly Effective (can't mist, only droplets)

3 – Moderately Effective (mist can reach mid-air only)

4 – Very Effective (mist is knee-level above the ground surface)

5 – Extremely Effective (mist can reach ground surface)

The researchers established the following hypothesis:

H_o: There is no significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of effectiveness.

H_a: There is a significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of effectiveness.

Factor 2: Software Efficiency

Software efficiency refers to the quality of the intangible aspect of IoT-Based Automated Classroom Disinfection System. It determines the state of the software system whether it functions properly or not. The panel of raters rated the software efficiency of IoT-Based ACDS trial 1, trial 2, and trial 3 following the rating scale below.

1 – Very Poor

2 – Poor

3 – Acceptable

4 – Good

5 – Very Good

The researchers established the following hypothesis:

H_o: There is no significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of software efficiency.

H_a: There is a significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of software efficiency.

Factor 3: Hardware Efficiency

Hardware efficiency refers to the quality of the tangible aspect of IoT-Based Automated Classroom Disinfection System. It determines the state of the IoT-Based ACDS' hardware parts whether they function properly or not. The panel of raters rated the hardware efficiency of IoT-Based ACDS trial 1, trial 2, and trial 3 following the rating scale below.

1 – Very Poor

2 – Poor

3 – Acceptable

4 – Good

5 – Very Good

The researchers established the following hypothesis:

H_o: There is no significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of hardware efficiency.

H_a: There is a significant difference between the three trials of IoT-Based Automated Classroom Disinfection System in terms of hardware efficiency.

Rejection Rule:

If the computed F-value is lesser than the tabular value 5.14 level of significance, accept H_o reject H_a; if the computed F-value is greater than tabular value, reject H_o accept $H_{a.}$

CHAPTER 4

Results and Discussion

Test for Technological Properties

Factor 1: Effectiveness

Effectiveness refers to the area coverage and misting capability of IoT-Based Automated Classroom Disinfection System. It ensures if IoT-Based ACDS is misting effectively or not.

A panel of raters were asked to rate the effectiveness of IoT-Based Automated Classroom Disinfection System and the results are the following:

Table 2: Result of Effectiveness Test in IoT-Based Automated Classroom Disinfection System

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	5	4	5	4.67
Trial 2	5	5	5	5

Trial 3	5	5	5	5

Table 1 shows the effectiveness test conducted on IoT-Based Automated Classroom Disinfection System. The rating 5 indicates that the IoT-Based ACDS is extremely effective which implies that the mist can reach the ground surface. While, rating 4 indicates that the IoT-Based ACDS is very effective which concludes that the mist can reach knee level above the ground surface.

Referring to Table 1, it shows that the mean indicates that the IoT-Based Automated Classroom Disinfection System has an effective misting capability that can reach down to the ground surface.

Table 3. The One-Way ANOVA Table

Product	Mean	Computed F-Value	F-Critical	Interpretation
IoT-BASED ACDS	4.67	0.99	5.14	Insignificant

As shown in Table 2, the computed f-value which is 0.99 is lesser than the critical value which is 5.14. Therefore, the research hypothesis which states that the three trials of IoT-Based Automated Classroom Disinfection System differ significantly in each other in terms of effectiveness will be rejected. Meaning, the null hypothesis will be accepted, the three trials of IoT-Based ACDS differ insignificantly in terms of effectiveness.

Factor 2: Software Efficiency

Software efficiency refers to the quality of the intangible aspect of IoT-Based Automated Classroom Disinfection System. It determines the state of the software system whether it functions properly or not.

A panel of raters were asked to rate the software efficiency of IoT-Based Automated Classroom Disinfection System and the results are the following:

Table 4: Result of Software Efficiency Test in IoT-Based Automated Classroom Disinfection System

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	5	5	5	5
Trial 2	5	5	5	5

Trial 3	5	5	5	5

Table 3 shows the software efficiency test conducted on IoT-Based Automated Classroom Disinfection System. The rating 5 indicates that the IoT-Based ACDS is in a very good condition in software system.

Referring to Table 3, it shows that the mean indicates that the IoT-Based Automated Classroom Disinfection System has an efficient and effective software system.

Table 5. The One-Way ANOVA Table

Product	Mean	Computed F-Value	F-Critical	Interpretation
IoT-BASED ACDS	5	0	5.14	Insignificant

As shown in Table 4, the computed f-value which is 0 is lesser than the critical value which is 5.14. Therefore, the research hypothesis which states that the three trials of IoT-Based Automated Classroom Disinfection System differ significantly in each other in terms of software efficiency will be rejected. Meaning, the null hypothesis will be accepted, the three trials of IoT-Based ACDS differ insignificantly in terms of software efficiency.

Factor 3: Hardware Efficiency

Hardware efficiency refers to the quality of the tangible aspect of IoT-Based Automated Classroom Disinfection System. It determines the state of the IoT-Based ACDS' hardware parts whether they function properly or not.

A panel of raters were asked to rate the hardware efficiency of IoT-Based Automated Classroom Disinfection System and the results are the following:

Table 6: Result of Hardware Efficiency Test in IoT-Based Automated Classroom Disinfection System

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	4	5	5	4.67
Trial 2	5	4	4	4.3
Trial 3	5	4	4	4.3

Table 5 shows the hardware efficiency test conducted on IoT-Based Automated Classroom Disinfection System. The rating 5 indicates that the IoT-Based ACDS is in a very good condition in hardware efficiency, and rating 4 indicates only good condition.

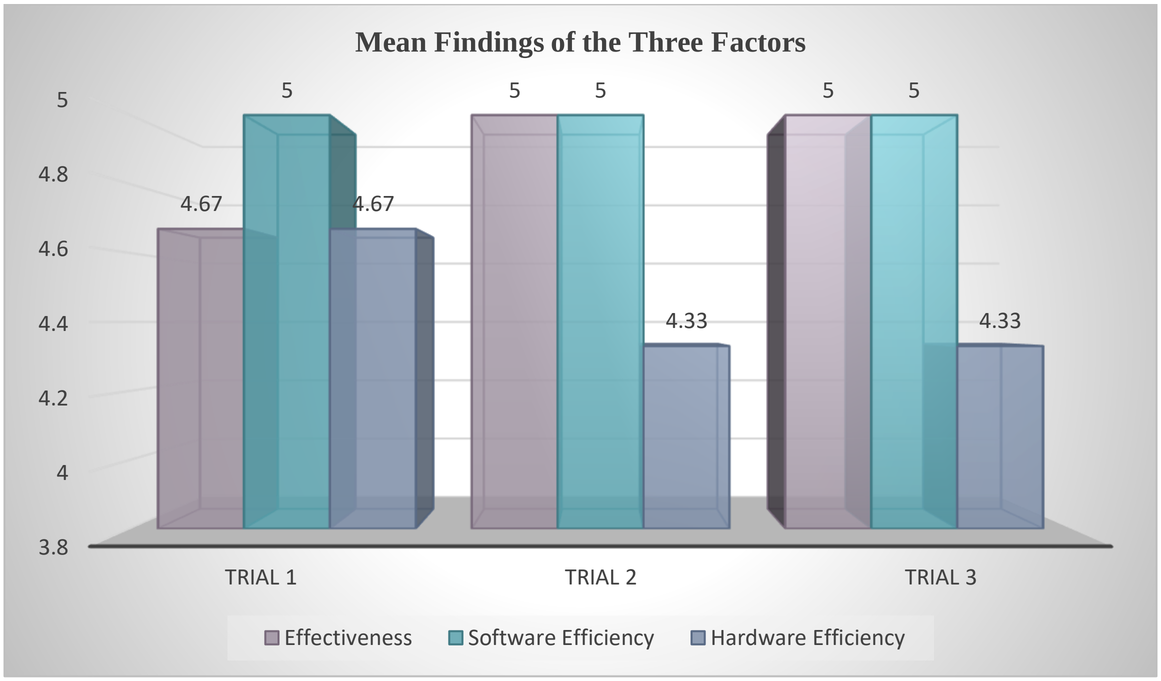
Referring to Table 3, it shows that the mean indicates that the IoT-Based Automated Classroom Disinfection System is in a good condition in terms of hardware efficiency.

Table 7. The One-Way ANOVA Table

Product	Mean	Computed F-Value	F-Critical	Interpretation
IoT-BASED ACDS	5	0.33	5.14	Insignificant

As shown in Table 6, the computed f-value which is 0.33 is lesser than the critical value which is 5.14. Therefore, the research hypothesis which states that the three trials of IoT-Based Automated Classroom Disinfection System differ significantly in each other in terms of hardware efficiency will be rejected. Meaning, the null hypothesis will be accepted, the three trials of IoT-Based ACDS differ insignificantly in terms of hardware efficiency.

Graph 1. Bar Graph of the Mean Findings of the Three Factors



Effectiveness	Software Efficiency	Hardware Efficiency
Trial 1: 4.67	Trial 1: 5	Trial 1: 4.67
Trial 2: 5	Trial 2: 5	Trial 2: 4.33
Trial 3: 5	Trial 3: 5	Trial 3: 4.33

Graph 1 shows the overall means of the three factors which is the effectiveness, software efficiency and, hardware efficiency. The computed mean value of the first, second and third trial of IoT-Based Automated Classroom Disinfection System in terms of effectiveness is 4.67, 5, and 5 respectively. While, the computed mean value of the three trials of IoT-Based ACDS in terms of software efficiency is all 5. Lastly, in hardware efficiency is 4.67, 4.33, and 4.33 respectively.

CHAPTER 5

Summary of Findings, Conclusions and Recommendations

Summary of Findings

The main objective of the study was to investigate the potential of IoT-Based Automated Classroom Disinfection System as an efficient modern decontamination system. Based on the gathered, analysed, and interpreted data, the researchers came up with the following findings presented in accordance with the statement of the problem. This study was summarized in the following significant statements.

1. It was found out that IoT-Based Automated Classroom Disinfection System was an efficient modern decontamination system. Together with the software and hardware aspect, being the most critical foundation of achieving the research product, it formed an effective disinfection system which can be depended in terms of effectiveness, software efficiency, and hardware efficiency.

2. With the raw data gathered together, it was found out that IoT-Based Automated Classroom Disinfection System was highly capable in classroom setting decontamination in terms of effectiveness, software efficiency, and hardware efficiency. All research hypotheses which state that the three trials of IoT-Based ACDS differ significantly in each other in terms of effectiveness, software efficiency, and hardware efficiency were rejected. Meaning, all null hypothesis were accepted, concluding that the three trials of IoT-Based ACDS do not differ significantly in each other in terms of effectiveness, software efficiency, and hardware efficiency.

3. The advantages of having IoT-Based Automated Classroom Disinfection System in a classroom setting includes lessening the work of manual disinfection operators, efficiently disinfecting room area, and effectively check the decontamination history, room's humidity, temperature, and disinfectant volume level using the IoT-Based monitoring app. It was also found out that it can have some disadvantages such as the varying strength of signal connection while using the system,

difficulties of installing the system, and errors of the system that might happen because of the hardware parts' poor quality.

Conclusions

Based on the statistical analysis, it was found out that IoT-Based Automated Classroom Disinfection System was an efficient modern decontamination system and highly capable in terms of effectiveness, software efficiency, and hardware efficiency. During the trial testing of the system, it was observed that it has various advantages and disadvantages as well. It was also discovered that the ratio of the number of nozzles and room area between the stockroom and classroom respectively was 6.167 ft. X 3.417 ft. : 1 nozzle = 30 ft. X 23 feet : 24 nozzles. Meaning, there were assumed 24 nozzles to be used in a typical classroom setting.

Recommendations

To further enhance or modify this research study, the researchers present the following recommendations:

1. During the researchers, trials or experiments, the researchers had some Wi-Fi difficulties. In regrading to wireless network, we propose to use Bluetooth as an alternative. Although Wi-Fi is a lot more accessible because you can still have access even from far distances, however it can catch noises and delays to the ACD's performance. Meanwhile, if Bluetooth are connected, even though it only has a short range, it builds personal area network where no noises can interrupt your device's performance.

2. As to the researchers' installation of the device you can modify it by making the external more functioning. In this study, the device is attached to the wall. The researchers suggest to make the device movable. It would've been better if this device can move from one place to another, you can also always program the nozzles to make it movable as well to have better coverage to the area.

3. The researchers recommend to build the device's its own server. In this study, the researchers used the server or platform of Blynk IoT. It did offer remote access for controlling and monitoring the ACD, but by installing your own server, you may have more precise device synchronization and allowed access management. Have your own application, with your own server, not linked from any platform or public server. With your own application, one may arrange and plan the data gathering from the device itself. You can update or modify the device with the help of an application you develop along with the server.

Appendix A

Letter of Approval

BANTAYAN SCIENCE HIGH SCHOOL

Ticad, Bantayan, Cebu

Dear Panelist: April 3,2023

Greetings!

We would like to request you as our panelist and rate our IoT-Based Automated Classroom Disinfector, the product of our Research Project at Bantayan Science High School Biology Laboratory. We hope that you accept our request. Your cooperation in this project is deeply appreciated. Thank you and God speed!

Yours truly,

Kyla Marie S. Abello

Kimberly Necesario

Reiner Aloyan

Alexa Jane S. Sandigan

Anthony Earl M. Avenido

Stephenn Andrei Santillan

Nhel Diane Desucatan

Shawn Kizzy Vinzon

Cris Anne Inoy

Approved by:

(Name of Rating Judge)

Rating Judge

Appendix B

Sample Rating Sheet

RATING SHEET

Name of Panelist: ________________________________ Date: ___________________

Title of Experimental Research: "IoT-Based Automated Classroom Disinfection System"

You are presented one set-up – Set-up A (IoT-Based Automated Classroom Disinfector). Kindly evaluate the effectiveness, software efficiency, and hardware efficiency by using the scales given. Write the numbers on the space on the table provided.

Effectiveness

Trials	IoT-Based Automated Classroom Disinfector (Set-up A)
1	
2	
3	
Average	

1 – Not at all Effective (can't mist at all)

2 – Slightly Effective (can't mist, only droplets)

3 – Moderately Effective (mist can reach mid-air only)

4 – Very Effective (mist is knee-level above the ground surface)

5 – Extremely Effective (mist can reach ground surface)

Software Efficiency

Trials	IoT-Based Automated Classroom Disinfector (Set-up A)
1	
2	
3	
Average	

1 – Very Poor 3 – Acceptable 5 –Very Good

2 – Poor 4 – Good

Hardware Efficiency

Trials	IoT-Based Automated Classroom Disinfector (Set-up A)
1	
2	
3	
Average	

1 – Very Poor 3 – Acceptable 5 –Very Good

2 – Poor 4 – Good

____

Signature of Panelist

Appendix C

Computations

Factor 1: Effectiveness

One-Way ANOVA using hand to hand computation

Table 1: Findings of IoT-Based Automated Classroom Disinfection System in terms of Effectiveness.

IoT-BASED ACDS	PANELIST			MEAN
	1	2	3	
Trial 1	5	4	5	4.67
Trial 2	5	5	5	5
Trial 3	5	5	5	5

I. Degrees of freedom between and within groups

Between Groups Degrees of Freedom: DF = k − 1, where k is the number of groups

Within Groups Degrees of Freedom: DF = N − k, where N is the total number of subjects Total Degrees of Freedom: DF = N − 1

$DF_{between}$ = K-1

$DF_{between}$ = 3-1

$DF_{between}$ = 2

DF_{within} = N-K

DF_{within} = 9-3

DF_{within} = 6

DF_{total} = 9-1

DF_{total} = 8

$F_{critical}$ = 5.14

$DF_{between}$ will serve as the nominator and DF_{within} will serve as the denominator in finding the $F_{critical}$ in F-table of Critical Values.

	F-table of Critical Values of α = 0.05 for F(df1, df2)													
	DF1=1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**15**	**20**	**24**
DF2=1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88	243.91	245.95	248.01	249.05
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11

II. Sum of squared deviation of the mean

$\bar{X}$ – indicates the overall mean

$\bar{X}_{i}$ – indicates the mean of the first trial

$\bar{X}_{ii}$ – indicates the mean of the second trial

$\bar{X}_{iii}$ – indicates the mean of the third trial

X_i – indicates the ratings of the first trial

X_{ii} – indicates the ratings of the second trial

X_{iii} – indicates the ratings of the second trial

$\bar{X} = 4.89$

$\bar{X}_i = 4.67$

$\bar{X}_{ii} = 5$

$\bar{X}_{iii} = 5$

Total sum of squares: SST = $\sum (x_i - \bar{x})^2$

SST = $(4 – 4.89)^2 + (5 – 4.89)^2 + (5 – 4.89)^2 + (5 – 4.89)^2 + (5 – 4.89)^2 + (5 – 4.89)^2 + (5 – 4.89)^2 +$

$(5 – 4.89)^2 + (5 – 4.89)^2$

SST = 0.89

Sum of Squares Within Groups: SSW = $\sum (x_i - \bar{x}_i)^2 (x_{ii} - \bar{x}_{ii})^2 (x_{ii} - \bar{x}_{iii})^2$

SSW = $(4 – 4.67)^2 + (5 – 4.67)^2 + (5 – 4.67)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 +$

$(5 – 5)^2$

SSW = 0.67

Sum of Squares Between Groups: SSB = SST – SSW

SSB = 0.89 – 0.67

SSB = 0.22

III. Variance Within and Between

Mean Square Between Groups: MSB = SSB / (k − 1)

MSB = 0.22 / (3 – 2)

MSB = 0.22 / 2

MSB = 0.11

Mean Square Within Groups: MSW = SSW / (N − k)

MSW = 0.67 / (9 – 3)

MSW = 0.67 / 6

MSW = 0.1116666667

F-Statistic (or F-ratio): F = MSB / MSW

IV.

F_{stat} = 0.11 / 0.1116666667

F_{stat} = 0.9850746266

$F_{stat} < F_{crit}$

0.9850746266 < 5.14

Therefore, the researcher failed to reject the null hypothesis, in other words accept Ho, reject Ha.

Factor 2: Software Efficiency

Table 2: Findings of IoT-Based Automated Classroom Disinfection System in terms of Software Efficiency.

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	5	5	5	5
Trial 2	5	5	5	5
Trial 3	5	5	5	5

I. Degrees of freedom between and within groups

Between Groups Degrees of Freedom: DF = k − 1, where k is the number of groups

Within Groups Degrees of Freedom: DF = N − k, where N is the total number of subjects Total Degrees of Freedom: DF = N − 1

$DF_{between}$ = K-1

$DF_{between}$ = 3-1

$DF_{between}$ = 2

DF_{within} = N-K

DF_{within} = 9-3

DF_{within} = 6

DF_{total} = 9-1

DF_{total} = 8

$F_{critical}$ = 5.14

II. Sum of squared deviation of the mean

$\bar{X}$ – indicates the overall mean

$\bar{X}_i$ – indicates the mean of the first trial

$\bar{X}_{ii}$ – indicates the mean of the second trial

$\bar{X}_{iii}$ – indicates the mean of the third trial

Xi – idicates the ratings of the first trial

Xii – indicates the ratings of the second trial

Xiii – indicates the ratings of the second trial

$\bar{X}$ = 5

$\bar{Xi} = 5$

$\bar{Xii} = 5$

$\bar{Xiii} = 5$

Total sum of squares: SST = $\sum(x_i - \bar{x})^2$

SST = $(5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2$

SST = 0

Sum of Squares Within Groups: SSW = $\sum(x_i - \bar{xi})^2 (x_{ii} - \bar{xii})^2 (x_{ii} - \bar{xiii})^2$

SSW = $(5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2 + (5 – 5)^2$

SSW = 0

Sum of Squares Between Groups: SSB = SST – SSW

SSB = 0 - 0

SSB = 0

III. Variance Within and Between

Mean Square Between Groups: MSB = SSB / (k − 1)

MSB = 0 / (3 – 2)

MSB = 0 / 2

MSB = 0

Mean Square Within Groups: MSW = SSW / (N − k)

MSW = 0 / (9 – 3)

MSW = 0 / 6

MSW = 0

IV.

F-Statistic (or F-ratio): F = MSB / MSW

$F_{stat} = 0 / 0$

$F_{stat} = 0$

$F_{stat} < F_{crit}$

$0 < 5.14$

Therefore, the researcher failed to reject the null hypothesis, in other words accept Ho, reject Ha.

Factor 3: Hardware Efficiency

Table 3: Findings of IoT-Based Automated Classroom Disinfection System in terms of Hardware Efficiency.

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	4	5	5	4.67
Trial 2	5	4	4	4.3
Trial 3	5	4	4	4.3

I. **Degrees of freedom between and within groups**

Between Groups Degrees of Freedom: $DF = k - 1$, where k is the number of groups

Within Groups Degrees of Freedom: $DF = N - k$, where N is the total number of subjects Total Degrees of Freedom: $DF = N - 1$

$DF_{between} = K-1$

$DF_{between} = 3-1$

$DF_{between} = 2$

$DF_{within} = N-K$

$DF_{within} = 9-3$

$DF_{within} = 6$

$DF_{total} = 9-1$

$DF_{total} = 8$

$F_{critical} = 5.14$

II. **Sum of squared deviation of the mean**

$\bar{X}$ – indicates the overall mean

$\bar{X}i$ – indicates the mean of the first trial

$\bar{X}ii$ – indicates the mean of the second trial

$\bar{X}iii$ – indicates the mean of the third trial

Xi – indicates the ratings of the first trial

Xii – indicates the ratings of the second trial

Xiii – indicates the ratings of the second trial

X^{-} = 4.44

Xi^{-} = 4.67

Xii^{-} = 4.33

$Xiii^{-}$ = 4.33

Total sum of squares: SST = $\sum(x_i^{-} - x^{-})^2$

SST = $(4 - 4.44)^2 + (5 - 4.44)^2 + (5 - 4.44)^2 + (5 - 4.44)^2 + (4 - 4.44)^2 + (4 - 4.44)^2 + (5 - 4.44)^2 + (4 - 4.44)^2 + (4 - 4.44)^2$

SST = 2.22

Sum of Squares Within Groups: SSW = $\sum(x_i - xi^{-})^2 (x_{ii} - xii^{-})^2 (x_{ii} - xiii^{-})^2$

SSW = $(4 - 4.67)^2 + (5 - 4.67)^2 + (5 - 4.67)^2 + (5 - 4.33)^2 + (4 - 4.33)^2 + (4 - 4.33)^2 + (5 - 4.33)^2 + (4 - 4.33)^2 + (4 - 4.33)^2$

SSW = 2.00

Sum of Squares Between Groups: SSB = SST – SSW

SSB = 2.22 – 2.00

SSB = 0.22

III. Variance Within and Between

Mean Square Between Groups: MSB = SSB / (k − 1)

MSB = 0.22 / (3 – 2)

MSB = 0.22 / 2

MSB = 0.11

Mean Square Within Groups: MSW = SSW / (N − k)

MSW = 2.00 / (9 – 3)

MSW = 2.00 / 6

MSW = 0.3333333333

IV.

F-Statistic (or F-ratio): F = MSB / MSW

Fstat = 0.11 / 0.3333333333

Fstat = 0.33

Fstat < Fcrit

0.33 < 5.14

Therefore, the researcher failed to reject the null hypothesis, in other words accept Ho, reject Ha.

One-Way ANOVA using SPSS

Table 1: Findings of IoT-Based Automated Classroom Disinfection System in terms of Effectiveness.

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	5	4	5	4.67
Trial 2	5	5	5	5
Trial 3	5	5	5	5

Descriptives

Effectiveness

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
trial 1 only		3	4.67	.577	.333	3.23	6.10	4	5	
trial 2 only		3	5.00	.000	.000	5.00	5.00	5	5	
trial 3 only		3	5.00	.000	.000	5.00	5.00	5	5	
Total		9	4.89	.333	.111	4.63	5.15	4	5	
Model	Fixed Effects			.333	.111	4.62	5.16			
	Random Effects				.111[a]	4.41[a]	5.37[a]			.000

a. Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.

Descriptives

Effectiveness

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
trial 1 only		3	4.67	.577	.333	3.23	6.10	4	5	
trial 2 only		3	5.00	.000	.000	5.00	5.00	5	5	
tial 3 only		3	5.00	.000	.000	5.00	5.00	5	5	
Total		9	4.89	.333	.111	4.63	5.15	4	5	
Model	Fixed Effects			.333	.111	4.62	5.16			
	Random Effects				.111[a]	4.41[a]	5.37[a]			.000

a. Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Effectiveness	Based on Mean	16.000	2	6	.004
	Based on Median	1.000	2	6	.422
	Based on Median and with adjusted df	1.000	2	2.000	.500
	Based on trimmed mean	12.603	2	6	.007

ANOVA

Effectiveness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.222	2	.111	1.000	.422
Within Groups	.667	6	.111		
Total	.889	8			

Table 2: Findings of IoT-Based Automated Classroom Disinfection System in terms of Software Efficiency.

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	5	5	5	5
Trial 2	5	5	5	5
Trial 3	5	5	5	5

Descriptives

Software

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
trial 1 only	3	5.00	.000	.000	5.00	5.00	5	5
trial 2 only	3	5.00	.000	.000	5.00	5.00	5	5
tial 3 only	3	5.00	.000	.000	5.00	5.00	5	5
Total	9	5.00	.000	.000	5.00	5.00	5	5

ANOVA

Software

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	2	.000	.	.
Within Groups	.000	6	.000		
Total	.000	8			

Table 3: Findings of IoT-Based Automated Classroom Disinfection System in terms of Hardware Efficiency.

IoT-BASED ACDS	PANELISTS			MEAN
	1	2	3	
Trial 1	4	5	5	4.67
Trial 2	5	4	4	4.3
Trial 3	5	4	4	4.3

Descriptives

Hardware

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
trial 1 only		3	4.67	.577	.333	3.23	6.10	4	5	
trial 2 only		3	4.33	.577	.333	2.90	5.77	4	5	
tial 3 only		3	4.33	.577	.333	2.90	5.77	4	5	
Total		9	4.44	.527	.176	4.04	4.85	4	5	
Model	Fixed Effects			.577	.192	3.97	4.92			
	Random Effects				.192[a]	3.62[a]	5.27[a]			-.074

a. Warning: Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Hardware	Based on Mean	.000	2	6	1.000
	Based on Median	.000	2	6	1.000
	Based on Median and with adjusted df	.000	2	6.000	1.000
	Based on trimmed mean	.000	2	6	1.000

ANOVA

Hardware

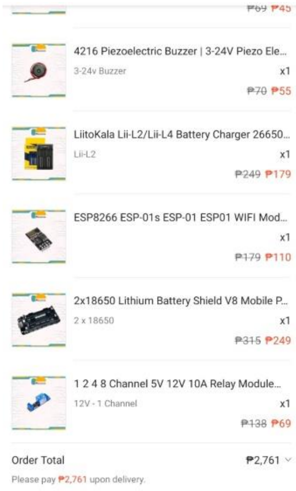
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.222	2	.111	.333	.729
Within Groups	2.000	6	.333		
Total	2.222	8			

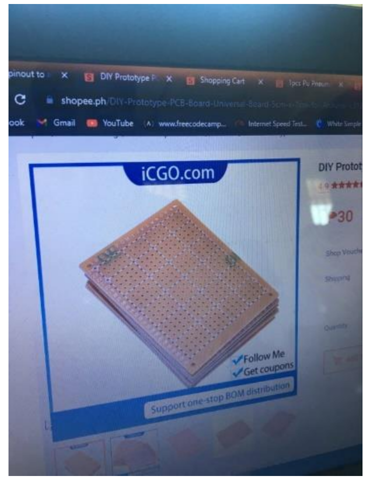
Appendix D

Documentations

Phase I. Preparation of Making the Automated Classroom Disinfector (ACD)

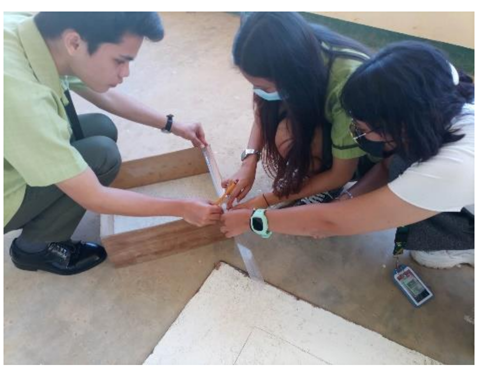
A. Preparation of Materials





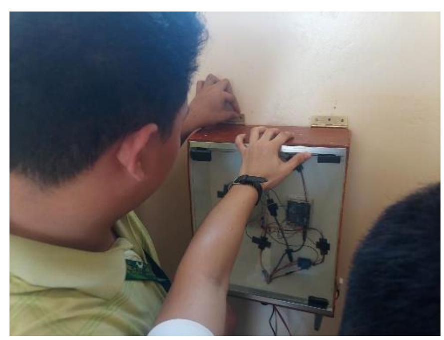
Materials were ordered online and other materials were purchased in various local hardware stores in Bantayan Island.

B. Fabrication of the Device

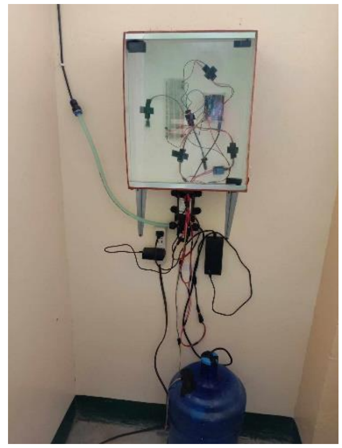


The box was made out of plywood which was handmade by the researchers.

The Arduino and the other sensors were placed inside the box.



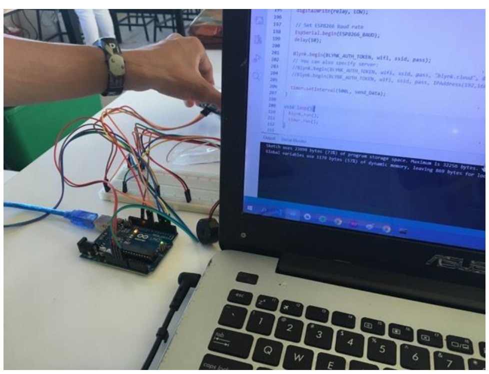
After the controller was finished, it was placed and drilled on a wall.



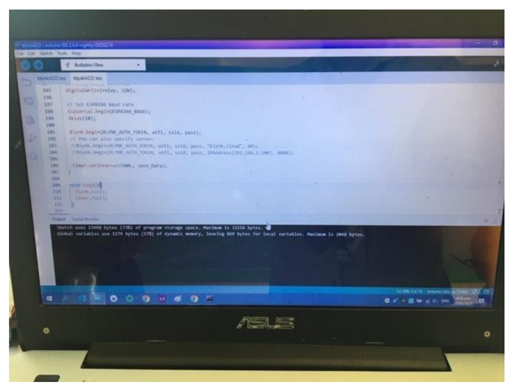
Afterwards, the misting kit was installed on the ceiling for better coverage.

The water pump was also mounted on the wall and underneath was the liquid container.

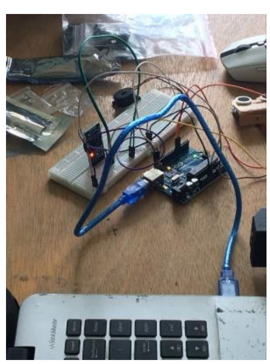
C. Programming



Personal computer of the researcher was used in programming.



The researchers programmed an algorithm that suited the device function.



Then, the researchers uploaded the code to the Arduino.

D. Setting up Blynk Server Time, Relay Module, Water Pump

```
const int buzzer = 5;
const int relay = 12;
int LowLevel = 38;
int HighLevel = 5; //cm
float levelCM;
int Level1 = (LowLevel * 90) / 100;  //low level
#define TRIGPIN 9
#define ECHOPIN 8

// Digital clock display of the time
void clockDisplay() {
  // You can call hour(), minute(), ... at any time
  // Please see Time library examples for details

  String currentTime = "TIME:" + String(hour()) + ":" + minute() + ":" + second();
  String currentDate = "DATE:" + String(month()) + " " + day() + " " + year();

  //send time data to blynk app
  Blynk.virtualWrite(V0, currentTime);
  Blynk.virtualWrite(V2, currentDate);
}

}
```

```
void setup() {

  // Set ESP8266 baud rate
  EspSerial.begin(ESP8266_BAUD);
  delay(10);

  Blynk.begin(BLYNK_AUTH_TOKEN, wifi, ssid, pass);
  // You can also specify server:
  //Blynk.begin(BLYNK_AUTH_TOKEN, wifi, ssid, pass, "blynk.cloud", 80);
  //Blynk.begin(BLYNK_AUTH_TOKEN, wifi, ssid, pass, IPAddress(192,168,1,100), 8080);

  setSyncInterval(10 * 60);  // Sync interval in seconds (10 minutes)

}

void loop() {
  // put your main code here, to run repeatedly:
  float distanceIN = ultrasonic.getDistanceIN();
  levelCM = convertToCM(distanceIN);

  //alarm when low level
  if(Level1 <= levelCM){
    digitalWrite(relay, LOW);
    tone(buzzer, 1000);
    delay(100);
    noTone(buzzer);
    delay(100);
  }
```

```
else {
  noTone(buzzer);
}

//converts into percentage
levelCM = levelCM/(LowLevel - HighLevel);
levelCM = levelCM * 100;
int percentageLevel = 100 - levelCM;
if (percentageLevel > 100) {percentageLevel = 100;}
int blynkLevelPercentage = percentageLevel;

if (percentageLevel <= 100) {
  Blynk.virtualWrite(V4, blynkLevelPercentage);
} else {
  Blynk.virtualWrite(V4, 0);
}

}
```

The server time, relay module, and water pump were set by the researchers to program their desired functions.

E. Setting up the Buzzer and Ultrasonic Sensor

```
if(Relay == 1){
  digitalWrite(relay, HIGH);
  Serial.println("PUMP ON");
  tone(buzzer, 10000);
} else {
  digitalWrite(relay, LOW);
  Serial.println("PUMP OFF");
  noTone(buzzer);
}

//alarm when low level
if(Level1 <= levelCM){
  digitalWrite(relay, LOW);
  tone(buzzer, 1000);
  delay(100);
  noTone(buzzer);
  delay(100);
}
else {
  noTone(buzzer);
}
```

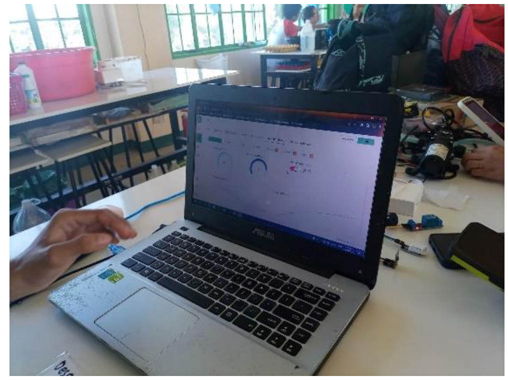
```
float distanceIN = ultrasonic.getDistanceIN();
levelCM = convertToCM(distanceIN);

//converts into percentage
levelCM = levelCM/(LowLevel - HighLevel);
levelCM = levelCM * 100;
int percentageLevel = 100 - levelCM;
if (percentageLevel > 100) {percentageLevel = 100;}
int blynkLevelPercentage = percentageLevel;

if (percentageLevel <= 100) {
  Blynk.virtualWrite(V4, blynkLevelPercentage);
} else {
  Blynk.virtualWrite(V4, 0);
}
```

The Ultrasonic Sensor was set up to detect the water level of the liquid container.

The buzzer was also set up to make sounds before pump on and after pump off during the misting, and also when the water level is low.

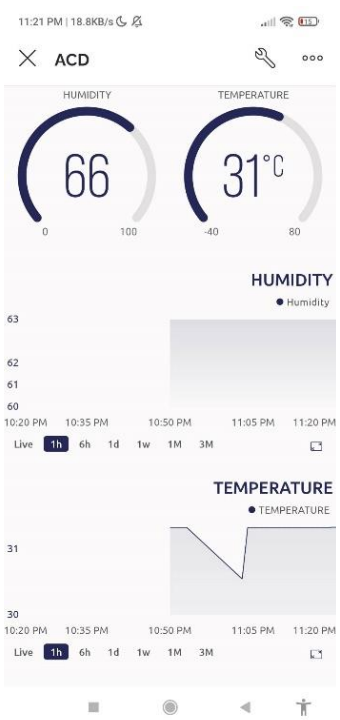
F. Setting up the WI-FI Module and Blynk ACD App

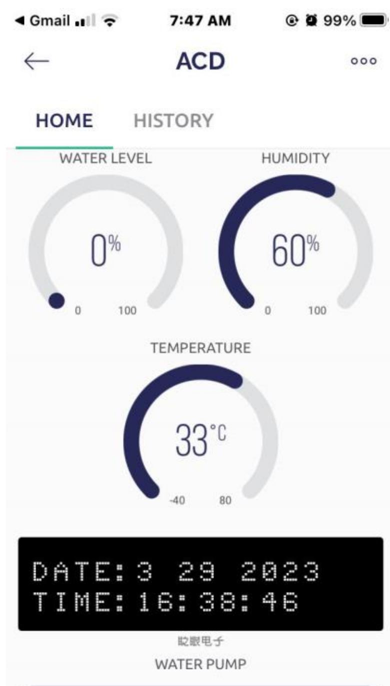
```
char ssid[] = "do not touch";
char pass[] = "**********";

#include <SoftwareSerial.h>
SoftwareSerial EspSerial(2, 3);  // RX, TX

ESP8266 wifi(&EspSerial);

BLYNK_CONNECTED() {
  Serial.print("CONNECTED");
  Blynk.syncAll();
  rtc.begin();
}

void setup() {

  // Set ESP8266 baud rate
  EspSerial.begin(ESP8266_BAUD);
  delay(10);

  Blynk.begin(BLYNK_AUTH_TOKEN, wifi, ssid, pass);
  // You can also specify server:
  //Blynk.begin(BLYNK_AUTH_TOKEN, wifi, ssid, pass, "blynk.cloud", 80);
  //Blynk.begin(BLYNK_AUTH_TOKEN, wifi, ssid, pass, IPAddress(192,168,1,100), 8080);

  setSyncInterval(10 * 60);  // Sync interval in seconds (10 minutes)

}
```



The researchers then set up the WI-FI module to have WI-FI connection of the IoT-Based ACD system.

The researchers also set up the IoT-Based ACDS's App using the Blynk Server.

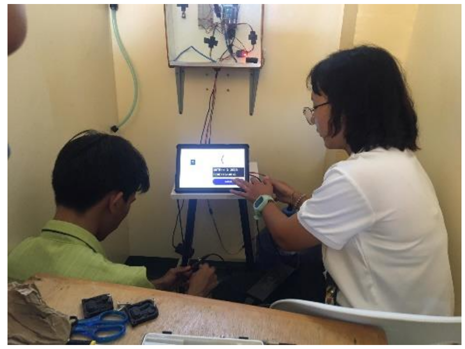




The app was programed to show data like humidity, temperature, and history of misting. It also can start manually and automatically (set time) pump on and start the misting process.

G. Testing and Debugging

The researchers first tested the water pump if it works and how the hose and nozzles handled it.



The researchers then tested the whole system inside the prototyped room that is scaled the size of an actual classroom.

H. Measuring the Area of the Stockroom and Classroom

Lastly, the researchers measured the area of the school stockroom and classroom to identify the number of nozzles needed per area coverage by comparing the area of the stockroom and typical classroom setting.

Phase II. Tests for Technological Properties



In the rating of process, three panelists were chosen to rate our IoT-Based ACDS in terms of effectiveness, software efficiency, and hardware efficiency in three trials.

Appendix E

Budget Matrix

Quantity	Item	Unit	Price per Unit	Total
1	1. Glass	Piece	₱ 250.00	₱ 250.00
1	2. Adaptor	Piece	₱ 32.00	₱ 32.00
1	3. Adhesive Tape	Piece	₱ 20.00	₱ 20.00
1	4. Paint Brush	Piece	₱ 25.00	₱ 25.00
2	5. White Paint	Cans	₱ 30.00	₱ 60.00
1	6. 12V 6A Adapter	Piece	₱ 355.00	₱ 355.00
2	7. Connector	Pieces	₱ 80.00	₱ 160.00
1	8. 130 PSI Pump	Piece	₱ 448.00	₱ 448.00
1	9. Misting Kit	Set	₱ 347.00	₱ 347.00
1	10. Arduino Uno	Piece	₱ 649.00	₱ 649.00
1	11. RTC	Piece	₱ 125.00	₱ 125.00
1	12. Breadboard	Piece	₱ 65.00	₱ 65.00
120	13. Jumper Wires	Pieces	₱ 2.23	₱ 267.00
1	14. Lithium Ion Battery	Piece	₱ 185.00	₱ 185.00
1	15. DHT22	Piece	₱ 200.00	₱ 200.00
1	16. Ultrasonic Sensor	Piece	₱ 89.00	₱ 89.00
1	17. 9V 1A Adapter	Piece	₱ 119.00	₱ 119.00
1	18. Rocker Switch	Piece	₱ 29.00	₱ 29.00
1	19. Arduino Uno Case	Piece	₱ 45.00	₱ 45.00
1	20. Buzzer	Piece	₱ 55.00	₱ 55.00
1	21. ESP-01 Module	Piece	₱ 110.00	₱ 110.00
1	22. 12V 10A Relay	Piece	₱ 69.00	₱ 69.00
1	23. Alcohol	Gallon	₱ 497.00	₱ 497.00
1	24. Battery Charger	Piece	₱ 179.00	₱ 179.00
10	25. Resistor	Piece	₱ 1.00	₱ 10.00
1	26. 10mm Hose (1m)	Meter	₱ 60.00	₱ 60.00
5	27. Stranded Wire (5m)	Meter	₱ 16.00	₱ 80.00
1	28. Electrical Tape	Piece	₱ 55.00	₱ 55.00
1	29. Wood Glue	Piece	₱ 120.00	₱ 120.00
2	30. Bracket (Small)	Piece	₱ 6.00	₱ 12.00
2	31. Bracket (Large)	Piece	₱ 12.50	₱ 25.00
1	32. Plywood	Piece	₱ 100.00	₱ 100.00
2	33. Bondpaper (2ream)	Pieces	₱ 250.00	₱ 500.00
				GRAND TOTAL: ₱ 5,342.00

REFERENCES

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