POLYTECHNIC UNIVERSITY OF THE PHILIPPINES

THE EFFECTIVENESS OF UV LIGHTS IN DISINFECTING USING AN AUTOMATIC DISINFECTION BOX IMPLEMENTED WITH ARDUINO

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Chapter 1

THE PROBLEM AND ITS SETTING

This chapter introduces the problem and the setting of the study.

Introduction

In December of 2019 in Wuhan, China, an outbreak occurred due to the spread of the Novel Coronavirus. The virus spread at rapid rate and infect many people. Causing a great number of hospitalizations and casualties. The virus spread through-out the globe and recognized as global pandemic affecting more than 220 countries (Worldometer, 2021).

The Coronavirus cause a significant impact on disinfectant industry. Sudden rise in demand for sanitizers and disinfectant as a preventive measure against the virus has change the dynamic of the market (Reports and Data, 2020). The disinfectant demand imposes a challenge and concern to supply chain.

According to NationalAcademies (2021), ultraviolet lights specifically UVC, have the trait to inactivate SARS-CoV-2 and shows effectivity against reducing germs.

Cognizant of the growing problem, the researchers will develop and design an automatic disinfecting machine with UVC lamps as treating agent to disinfect materials or objects.

Theoretical Framework

The COVID-19 or coronavirus disease 2019 caused a pandemic that affected large numbers of people worldwide. Kitagawa et al. (2020), suggests that proper disinfection of SARS-CoV-2 contaminated surfaces helps prevent the spread.

According Kitagawa et al. (2020), the efficiency 222-nm UVC irradiation technology on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in unoccupied and occupied spaces can be used.

According to an in vitro experiment of Kitagawa et al. (2020), the 222-nm UVC irradiation in contaminated SARS-CoV-2 have significant effect. 0.1 mW/cm2 concentration of SARS-CoV-2 have been investigated after irradiating with 222 nm between 10 and 300 seconds in 50% infectious dose of tissue culture (TCID50). Quantitative transcription polymerase chain reaction is used to measure SARS-CoV-2 RNA with the same conditions.

The study has shown that 88.5 to 99.7% of SARS-CoV-2 has reduced based on the TCID50 test and resulted in one and 3 mJ/cm2 of 222-nm UVC irradiation for between 10 and 30 seconds. The test has also shown that SARS-CoV-2 RNA copies does not change after 5-minute irradiation of UVC.

The 222-nm UVC lamps is relatively safe for human skin interaction according to Nozomi et al. (2020). The 222-nm UVC suggests disinfecting ability is comparable with the 254-nm UVC causing cyclobutane pyrimidine dimers (CPDs) that lacerates DNA by ultraviolet.

The study has shown that 99.7% are reduced in SARS-CoV-2 after 30 second exposure to three 0.1 mW/cm2 222 nm UVC light according to the TCID50 test. The SARS-CoV-2 number does not change after the irradiation of ultraviolet.

Conceptual Framework

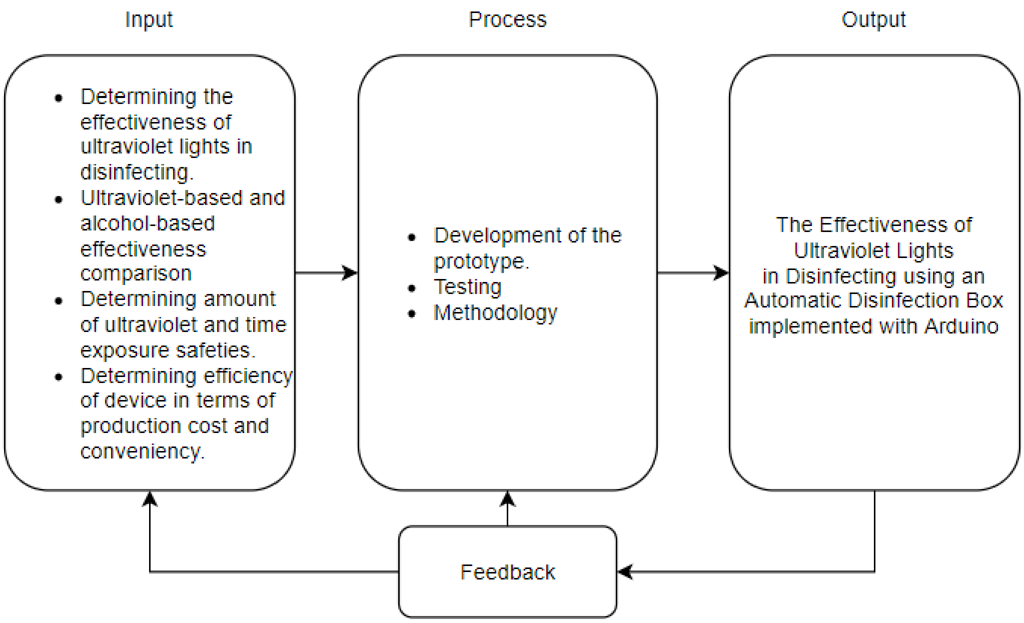

Figure 5: Conceptual Framework

Statement of the Problem

This study aims to determine the effectiveness of ultra violet lights in disinfecting using an automatic disinfection box.

Specifically, the study sought to find the answers to the following questions:

1. What is the significant difference between ultraviolet-based disinfectant and alcohol-based disinfectant in terms of their effectiveness?
2. What is the significant effect of ultraviolet intensity to be use in terms of its effectiveness?
3. What is the significant difference among the different duration in terms of its effectiveness?

a) 10 seconds

b) 20 seconds

c) 30 seconds

4. How does the automatic disinfection box be described in terms of?

   a) Satisfaction

   b) value for money

Hypothesis

The researchers lead up to the following hypothesis.

1. There is no significant difference between ultraviolet-based disinfectant and alcohol-based disinfectant in terms of their effectiveness.
2. There is no significant effect of ultraviolet intensity to be use in terms of its effectiveness.
3. There is no significant difference among the duration of 10 seconds, 20 seconds, and 30 seconds in terms of its effectiveness.

4a. The overall user rating of the device is very dissatisfied.

4b. The overall user rating of the device is it's not good value for money at all.

Scope and Limitations of the Study

The device will have a dimension of 72cm in height, 84cm in length, and 54cm in width. The tunnel entrance of the box will have a dimension of 55cm in height and 50cm in width. The device will have a conveyor belt to move the objects and provide controlled movement for automated disinfection. The conveyor belt will have an object sensor that will start to move the object inside the device and begin the disinfection.

This study will be limited to the comparison of effectiveness of ultraviolet-based disinfection with alcohol-based (70% alcohol content, isopropyl) disinfection, determining if there's a significant effect of ultraviolet intensity to be use in terms of its effectiveness, determining the significant difference among the duration of 10 seconds, 20 seconds, and 30 seconds in terms of its effectiveness, and determining the overall user rating of the device in terms of satisfaction and value for money.

The target sample for the experiment will be limited to Staphylococcus aureus.

The study will not cover the comparisons of effectiveness of ultraviolet-based disinfection and specific brands of alcohol. The study will not cover the comparisons of the effectiveness of ultraviolet-based disinfection and different alcohol content (beside 70% alcohol content) of specific brands of alcohol.

Significance of the Study

The Corona Virus Disease 2019 pandemic has increased the need for human disinfection. It is important to avoid reducing transmission risk. Thorough and efficient disinfection procedures must be implemented to return to our day-to-day operations cost-effectively.

Cognizant of the growing problem of stress, this study will be significant to the following:

1. **To health and safety officers** - automated disinfection promotes contactless, safe and good social distancing practice.

To help health and safety officers in maximization of time, effort, and funding in implementing health protocols by hastening and achieving optimal hygiene.

2. **To the user –** contactless disinfection

   To maintain proper hygiene with minimal contact, skin problems (e.g. drying), reduce hassle and space consumption (e.g. hand washing area) and achieve a higher level of disinfection.

3. **To the environment –** less plastic waste residue, reusable.

   To help reduce plastic and waste residues from alcohol plastic containers. Moreover, it helps reduce wastewater and water pollution.

4. **To the future researchers** – serves as good foundation of contactless. automatic and innovative method of disinfection.

   This innovation will provide greater insight into the potentials of automated innovation specifically in the maximization of materials, reduce human error, and increase efficacy rate.

Definition of Terms

The following key terms used in this study are defined for the purpose of clarification.

1. **Excimer lamps**. Ultraviolet light produced by spontaneous production of excimer molecules.
2. **Genotoxicity**. Cancer leading mutations cause by damaging genetic information.
3. **In vitro**. Artificial environment

4. **Staphylococcus aureus**. Primary leading cause of skin and soft tissue infections such as abscesses (boils), furuncles, and cellulitis.

Chapter 2

REVIEW OF LITERATURE AND STUDIES

This chapter contains documents, books, findings, academic and research journals that is related to the research.

Ultraviolet Disinfection

According to Childress J. (2021), the 254-nm UV light and 222-nm UV are germicidal light wavelengths that inactivate bacteria and viruses. Like standard 254-nm UVC, 222-nm UV light breaks the DNA bonds inside a microbe's nucleus, which can prevent microbes from replicating. Furthermore, 222-nm UV is highly absorbed by protein bonds in the membrane shells of microbes and human cells. This protein interaction makes 222-nm light effective at defeating microbes and much safer than 254-nm UV for human exposure. The data indicates that 222-nm light is much safer for humans than 254-nm light. This can allow 222-nm UV to be safely used when humans are present.

According to Childress J. (2021), Not all UV light is the same. Some UV wavelengths are better than others at disinfection, and some are safer for humans. Invisible to the human eye, UV is light at wavelengths shorter than 400 nm and greater than 100 nm. The UV spectrum is broken into sub-bands of UVA, UVB, and UVC. The UVA waveband is nearly visible and commonly called black light. UVB, a slightly shorter wavelength, is a major factor in getting sunburned and can cause skin cancer. Both UVA and UVB easily enter the earth's atmosphere and are present in sunlight. On the other hand, the UVC wavelengths, which are shorter than UVB, are blocked by the ozone in the earth's upper atmosphere and not typically present in sunlight at the earth's surface. This is important for germicidal effectiveness because it means microbes have fewer defenses against the shorter UVC wavelengths. Even within this UVC band, not all light is the same. According to studies at Columbia, UV light at the 222-nm wavelength has similar germicidal capabilities of the more widely used 254-nm UV light to kill or inactivate microbes (bacteria and viruses), but it does not produce the same damaging effects on skin or eyes as 254-nm light. This improved safety is because the shorter 222-nm UV wavelength has reduced penetration depth in human tissue. While the negative effects on humans are reduced, 222-nm light has increased performance for killing some bacteria and viruses.

According to Childress J. (2021), the output intensity of the 222 nm lamp can be varied by changing the input power, allowing the lamp to be instantly brightened or dimmed as required. Depending on design, excimer lamps can be run at power levels from as low as a few watts to kilowatts. To improve human safety even further, an optical filter can be added to remove small amounts of harmful wavelengths that might also have been generated above 230 nm.

Light from UVC systems is absorbed by DNA. The absorption of UVC by the DNA of a virus or bacteria damages its DNA, preventing the microbe from replicating. A microbe that cannot make copies of itself cannot cause harm. The 254-nm UV is highly absorbed by DNA but not easily absorbed by protein. This means that 254-nm light penetrates deeper into layers of protein-rich skin cells. While 254-nm UV damages microbe DNA, it can also penetrate deeper into human skin and damage the DNA of actively dividing skin cells. Damaged DNA in actively dividing human cells can lead to cancer (Childress J., 2021).

Furthermore, the 222-nm UV, on the other hand, is highly absorbed by both proteins and DNA. The outer membrane shell of all bacteria and viruses contains protein. Thus, 222-nm UV interacts not only with the DNA of the microbe but also the outer membrane shell of the microbes. Compared to 254-nm UVC, this dual mechanism of both DNA damage and protein shell interaction can increase the effectiveness of 222-nm UV against some microbes. It also makes it safer for humans.

All cells are rich in protein. Since 222-nm light is highly absorbed by protein, it cannot penetrate very far into thick layers of cells. The 222-nm light will fully penetrate viruses and bacteria but cannot penetrate the thick protein-rich outer layer of the skin, which is composed of dead skin cells. The outer layer of dead skin cells contains no active cells and much thicker than the largest bacteria or virus. This layer acts as an armor against 222-nm light. A similar outer protection layer of cells, the tear layer, protects the eyes. This makes 222-nm UV much safer for humans because the 222-nm light never reaches the DNA of active cells dividing inside the body. Since the 222-nm light does not reach actively dividing cells, it cannot cause cancer.

According to Geiger, the Duke Health researchers are using a portable machine called “Tru-D SmartUVC” to disinfect rooms of the patients. They have observed that there are bacteria that remained inside the patient rooms because of the patient that carried the organism inside the room. These bacteria are harmful because it can also affect the next patients that will occupy the same room. They have proven the effectivity of the usage of UVC lights using their portable machine as it not only disinfects patient rooms from viruses, they can also eradicate superbugs such as MRSA or Methicillin-resistant Staphylococcus aureus.

According to a study by Nozomi et al. (2020), 222-nm UVC lamps can be safely used for sterilizing human skin as far as the perspective of skin cancer development. Germicidal lamps that emit primarily 254 nm ultraviolet radiation (UV) are routinely utilized for surface sterilization but cannot be used for human skin because they cause genotoxicity. As an alternative, 222-nm UVC has been reported to exert sterilizing ability comparable to that of 254-nm UVC without producing cyclobutane pyrimidine dimers (CPDs), the major DNA lesions caused by UV. However, there has been no clear evidence for safety in chronic exposure to skin, particularly with respect to carcinogenesis. Nozomi et al investigated the long-term effects of 222-nm UVC on skin using highly photocarcinogenic phenotype mice that lack xeroderma pigmentosum complementation group A (Xpa-) gene, which is involved in repairing of CPDs. CPDs formation was recognized only uppermost layer of epidermis even with high dose of 222-nm UVC exposure. No tumors were observed in Xpa-knockout mice and wild-type mice by repetitive irradiation with 222-nm UVC, using a protocol which had shown to produce tumor in Xpa-knockout mice irradiated with broad-band UVB. Furthermore, erythema and ear swelling were not observed in both genotype mice following 222-nm UVC exposure.

According to Buonanno et al. (2020), a direct approach to limit airborne viral transmissions is to inactivate them within a short time of their production. Germicidal ultraviolet light, typically at 254 nm, is effective in this context but, used directly, can be a health hazard to skin and eyes. By contrast, far-UVC light (207–222 nm) efficiently kills pathogens potentially without harm to exposed human tissues. to Buonanno et al. (2020) demonstrated that 222-nm far-UVC light efficiently kills airborne influenza virus and we extend those studies to explore far-UVC efficacy against airborne human coronaviruses alpha HCoV-229E and beta HCoV-OC43. Low doses of 1.7 and 1.2 mJ/cm2 inactivated 99.9% of aerosolized coronavirus 229E and OC43, respectively. As all human coronaviruses have similar genomic sizes, far-UVC light would be expected to show similar inactivation efficiency against other human coronaviruses including SARS-CoV-2. Based on the beta-HCoV-OC43 results, continuous far-UVC exposure in occupied public locations at the current regulatory exposure limit (~3 mJ/cm2/hour) would result in ~90% viral inactivation in ~8 minutes, 95% in ~11 minutes, 99% in ~16 minutes and 99.9% inactivation in ~25 minutes. Thus, while staying within current regulatory dose limits, low-dose-rate far-UVC exposure can potentially safely provide a major reduction in the ambient level of airborne coronaviruses in occupied public locations.

According Kitagawa et al. (2020), the effectiveness of 222-nm UVC irradiation on viable SARS-CoV-2 suggest that this technology could be used for infection prevention and control against COVID-19, not only in unoccupied spaces but also occupied spaces.

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), has emerged as a serious threat to human health worldwide. Efficient disinfection of surfaces contaminated with SARS-CoV-2 may help prevent its spread. Kitagawa et al. (2020) aimed to investigate the in vitro efficacy of 222-nm far-ultraviolet light (UVC) on the disinfection of SARS-CoV-2 surface contamination.

Kitagawa et al. (2020) investigated the titer of SARS-CoV-2 after UV irradiation (0.1 mW/cm2) at 222 nm for 10-300 seconds using the 50% tissue culture infectious dose (TCID50). In addition, they used quantitative reverse transcription polymerase chain reaction to quantify SARS-CoV-2 RNA under the same conditions.

One and 3 mJ/cm2 of 222-nm UVC irradiation (0.1 mW/cm2 for 10 and 30 seconds) resulted in 88.5 and 99.7% reduction of viable SARS-CoV-2 based on the TCID50 assay, respectively. In contrast, the copy number of SARS-CoV-2 RNA did not change after UVC irradiation even after a 5-minute irradiation.

The study shows the efficacy of 222-nm UVC irradiation against SARS-CoV-2 contamination in an in vitro

McLeod (2020)

According to Buonnano et al., the exposure of 222nm can efficiently and safely inactivate the coronaviruses that will then become harmless for human interaction. It is said in their study that 254 nm is used more often in disinfecting coronavirus but can be harmful for humans due to its radiation. They demonstrated that 222 nm of UVC light can also efficiently inactivate the virus but is less harmful to humans unlike 254 nm. 1.7 and 1.2 mJ/c^2 doses of the 222 nm inactivated 99.9% of the aerosol coronaviruses and other human coronaviruses like SARS-CoV 2.

According to Garcia et al., UV-C (Ultraviolet C) lights are proven to sanitize different surfaces reached by the said lighting and can also eradicate different viruses and bacteria such as escherichia coli. With only 10 minutes of exposure to the said light with the intensity of 0.15 - 0.4 W/m^2, it is proven to remove harmful bacteria such as e-coli. UV-C is capable of inactivating the bacteria within the 167cm distance from the UV-C lamp. Though UV-C was proven and tested to sanitize surfaces from dangerous bacteria, the researchers said that the application of manual sanitation will make the UV-C lights most effective.

Based on the "Guidelines on UV Disinfection" by the Philippine Dermatology Society, the usage of UVGI (Ultraviolet Germicidal Irradiation) has captured the interests of different groups in efforts of reducing the spread of infection that transfers itself to another host by the means of touching or getting exposed to an infected item wherein a person uses or interacts a device or item that a Covid-19 infected person has previously used. UVGI is currently being used to disinfect the air and surfaces in the attempt of providing extra precaution to people given that PPEs (Personal Protective Equipment) are not enough for the people working in the medical fields. Although UV exposure being dangerous to a person is a fact, with proper dilution of the radiation, it can be used to eradicate viruses at a microscopic level. With a dosage of 0.5 - 1.8 J/cm^2, viruses such as influenza (H1N1, H5N1, H7N9), MERS-CoV, and SARS-CoV are proven and tested to be disinfected and has little to no effect to other people. Though such viruses can be disinfected with only 0.5 J/cm^2, other authors urged the need to use at least 1 J/cm^2 on all surfaces to ensure the safety of the medical workers and prevent any exposure to lingering viruses attached to a surface.

According to Ramos et al. (2020), Because of its efficiency as a germicidal agent, UV-C has been proven to be a useful addition to terminal manual cleaning. More research is needed to establish a safe exposure dose standard, particularly for 222 nm germicidal lamps. Any targeted deployment of UV-C during the Coronavirus Disease 2019 (COVID-19) epidemic requires direct evidence.

According to Miranda et al. (2020) there has been research on the effectiveness of land mobile devices using UV technology in removing and deactivating pathogenic germs from contaminated surfaces in public areas by 60%. Only 40% of the studies included in this review found insufficient scientific evidence to establish the impact of UV technology on disease control in affected areas. This leads to the conclusion that there is enough research on the positive usage of this sort of technology in the control of contaminated area disinfection.

According to Eubania et al. (2021) Various UV-C lamps and Pulsed Xenon UVC (PX-UV) lamps were utilized in twelve research, including one cluster RCT, seven quasi-experimental studies, and four uncontrolled before and after studies. Because of research design flaws, imprecision, and a significant likelihood of bias, the overall certainty of evidence from these 12 studies was rated low.Only one study found a 44% decrease in viral infections among pediatric patients at that clinic. In ten of the 12 studies, UV-C was found to be an effective supplement to existing cleaning techniques, with the latter proving to be significantly more effective at eradicating bacteria

Ultraviolet Disinfection Machines

Paras E. (2020), created a device called Parazap, a portable Ultraviolet room disinfection unit that is electrically operated. The device is designed to disinfect PPEs, specifically N95 masks, killing almost 99% of microorganisms by means of exposure to ultraviolet (UV) radiation. It consists of two sets of UV-C germicidal lamps having 15 and 18-wattage and can accommodate up to10 N95 masks in one cycle. The UV-C chamber can also be adjusted according to duration of exposure – from 60seconds to 60 minutes depending on the prescribed length of exposure to kill a certain type of microorganism. All of the materials in making the equipment were locally available.

Zakaria F. (2016), studied Ultraviolet germicidal (short wavelength UV-C) light as surface disinfectant in an Emergency Sanitation Operation System® smart toilet to aid to the work of manual cleaning. The UV-C light was installed and regulated as a self-cleaning feature of the toilet, which automatically irradiate after each toilet use. Two experimental phases were conducted i.e., preparatory phase consists of tests under laboratory conditions and field-testing phase. The laboratory UV test indicated that irradiation for 10 min with medium–low intensity of 0.15–0.4 W/m2 could achieve 6.5 log removal of Escherichia coli. Field testing of the toilet under real usage found that UV-C irradiation was capable to inactivate total coliform at toilet surfaces within 167-cm distance from the UV-C lamp (UV-C dose between 1.88 and 2.74 mW). UV-C irradiation is most effective with the support of effective manual cleaning. Application of UV-C for surface disinfection in emergency toilets could potentially reduce public health risks.

Synthesis of the Reviewed Literature and Studies

Since 222-nm light is both deadly to microbes and safer for humans, it has the potential to be used in applications where humans are present during UV disinfection while still remaining within government UV exposure guidelines. The 222-nm lights can be installed in ceilings or walls and turned on when needed for disinfection. The UV lamp installation can be as large as a fluorescent light or as small as a smoke detector, depending on the desired speed of disinfection. The applications are limitless. A few examples include health facilities, visitor areas, office areas, food service areas, lavatories, and transport vehicles of all types (Figure 5). Almost any communal space can benefit from safe and effective disinfection that is automatic and uses no chemicals. Indicating the potential of 222-nm UV disinfection.

Chapter 3

METHODOLOGY

This chapter contains research design, methods and diagrams that will be used in the study.

Research Design

The researchers are use quantitative experimental research design for statement of the problem 1 to 3 in the study. According to Bhandari 2021, quantitative experimental research systematically tests causal relationships, collect and analyze numerical data and generalize results. Qualitative research design are used for statement of the problem 4. According to Acasestudy (2020)," Qualitative research targets on conveying meaning and comprehension via detailed description". The research designs will be used in the study.

T-test, one sample T-test, ANOVA and Likert scale are used for method of analysis. Disk diffusion technique and spread plate technique protocol are used in the experiment.

The target sample of the experiment is staphylococcus aureus.

Flowchart of Research Design/Process Flowchart

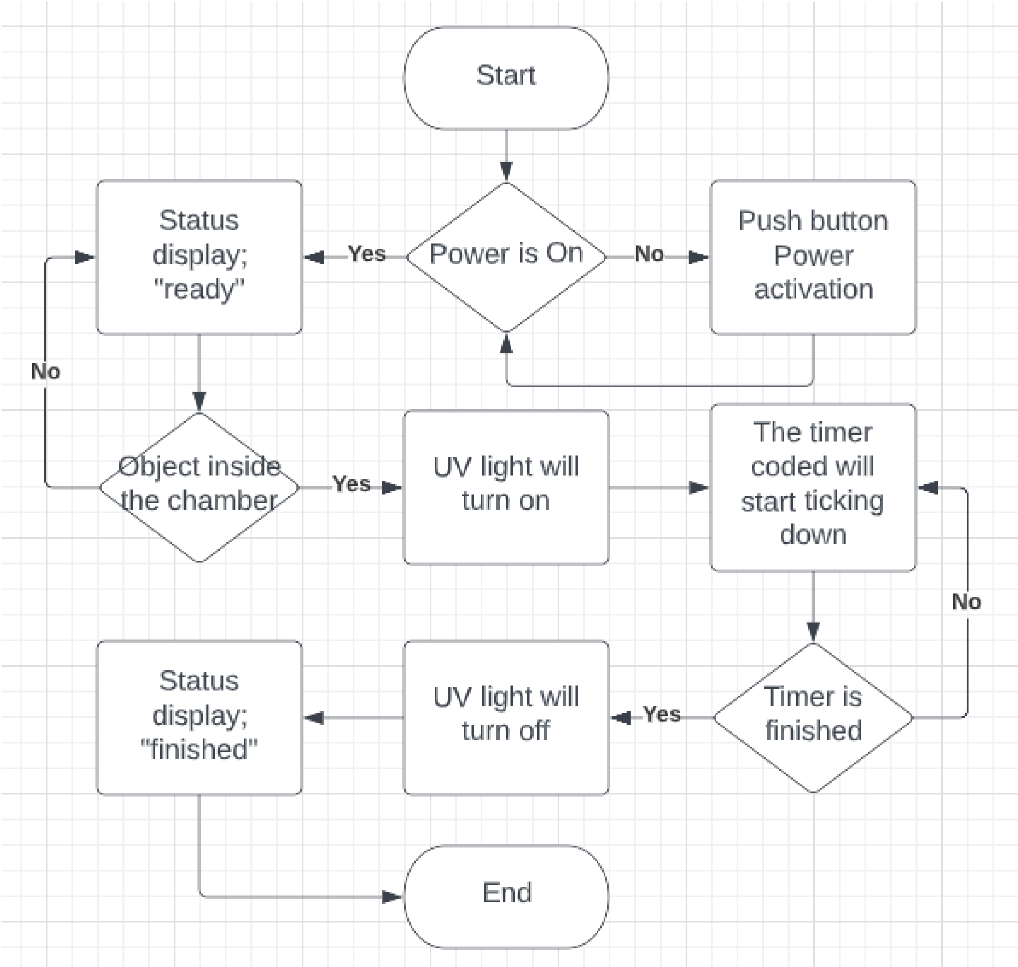

Figure 6: Research Design Flowchart

Description of Research Instrument Used

The t-test will be used in statement of the problem 1 to determine if there's a significant difference between the means of two groups. The One Sample t -test will be used in statement of the problem 2 to examine whether the mean of a population is statistically different from a known or hypothesized value. ANOVA will be used in statement of the problem 3a – 3b to determine if there are any statistical differences between the means of three or more independent groups. The Likert scale is will be used in statement of the problem 4a – 4b to allow participant to express how much they agree or disagree with the particular statement.

Statistical Treatment

T-test are used to test the significant difference between ultraviolet-based disinfectant and alcohol-based disinfectant in terms of their effectiveness. One sample t-test are used to test the significant effect of ultra violet intensity to be use used in terms of its effectiveness. ANOVA are used to determine the significant difference among the duration of 10 seconds, 20 seconds, and 30 seconds in terms of its effectiveness. Likert scale are used to determine the overall user rating of the automatic disinfection box in terms of satisfaction and value for money.

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APPENDICES

Appendix 1

LETTER OF INTENT

REPUBLIC OF THE PHILIPPINES
POLYTECHNIC UNIVERSITY OF THE PHILIPPINES
COLLEGE OF ENGINEERING
COMPUTER ENGINEERING DEPARTMENT

December 3, 2021

Engr. Julius S. Cansino
Chairperson, Computer Engineering Department
College of Engineering
Polytechnic University of the Philippines, Sta. Mesa

Dear Engr. Cansino:

Greeting in unvarying pursuit of academic excellence.

We, John Christopher B. Bagas, Charles Adriane S. Guerrero and Marcus M. Saralde, are bonafide 4th year Computer Engineering student from Polytechnic University of the Philippines and currently enrolled in Computer Engineering Practice and Design 1. The major requirement of this course is to identify possible research problems within the area and propose a solution to the identified problems.

On this note, we want to humbly ask for your permission that College of Engineering specifically, Computer Engineering Department, be the beneficiary of our study. The students will develop an **Automatic Disinfection Box Implemented with Arduino** which aim to reduce transmission risks and promote disinfection procedures. We are also respectfully requesting your assistance by allowing us deploy our prototype in the third floor of the college of engineering. In addition to that, we would also conduct interviews and or questionnaires if needed.

Should this request merit your considerate approval, be assured that any information shared by your institution will be treated with strict confidentiality.

We are hoping for your appropriate action and favorable response upon this matter.

Respectfully Yours,

John Christopher C. Bagas
Researcher, Computer Engineering Student

Charles Adriane S. Guerrero
Researcher, Computer Engineering Student

Marcus M. Saralde
Researcher, Computer Engineering Student

Michael John P. Pabanil
Researcher, Computer Engineering Student

Noted By:

Engr. Pedrito M. Tenerife Jr.
Adviser, Computer Engineering Practice and Design 1

Appendix 2

DESIGN PROJECT PROPOSAL DEFENSE 2021
SUMMARY OF COMMENTS
REPORT

NO.: CPERC-2021-PROP-POE-R-000060

GROUP CODE	3609	**ADVISER**	Engr. Pedrito M. Tenerife Jr.
SECTION	BSCpE 3-6		

THESIS TITLE	Development of Automatic Covid Disinfection Box Implemented with Arduino (ADB Automatic Disinfection Box)

	NAME OF PANEL
PANEL CHAIR	Dr. Remedios G. Ado
PANEL MEMBER 1	Engr. Arlene B. Canlas
PANEL MEMBER 2	Engr. Jonathan C. Manarang

	COMMENTS	**RECOMMENDATIONS**
PANEL CHAIR	Consider the comments and suggestions of the panel of evaluator to improve the project.	think of an alternative application solution to justify the need of this project & with 4 members in a team.
PANEL MEMBER 1	-	Consider adding how to verify the effectivity/ effectiveness of your disinfection device. Maximize the use of Arduino (example: sending sms about the status of the disinfection and the device)
PANEL MEMBER 2	Add gsm shield for sending message to the owner of the item being sanitized. Apply this prototype to laboratory subjects, include the counting of object being sanitized. Provide clinical lab test result in front of your subject to denote that it is calibra.	

NOTE: The data shown above are acquired from the filled-out Panel Evaluation Form in Google Forms. Should there be any error on this report, please notify the CpE Research Committee for verification.

Appendix 3

LETTER OF PERMISSION

REPUBLIC OF THE PHILIPPINES
POLYTECHNIC UNIVERSITY OF THE PHILIPPINES
COLLEGE OF ENGINEERING
COMPUTER ENGINEERING DEPARTMENT

March 23, 2022

Angel A. de Larrazabal, BSc, MD, MBA, FPCS, FACS
Medical Director
Qualimed Hospital

Madam de Larrazabal,

We, John Christopher B. Bagas, Charles Adriane S. Guerrero, Marcus M. Saralde, and Michael John P. Pabanil, are bonafide 4th-year Computer Engineering student from Polytechnic University of the Philippines currently enrolled in Computer Engineering Practice and Design 1. Our thesis entitled "The Effectiveness of Ultraviolet Lights in Disinfecting Using an Automatic Disinfection Box Implemented with Arduino" have led us to develop a prototype.

In connection with this, we are asking for your assistance to conduct the necessary laboratory testing for our prototype.

We are hoping for your kind consideration regarding the matter stated above. Thank you and God bless.

Sincerely,

John Christopher B. Bagas
Researcher, Computer Engineering Student

Charles Adriane S. Guerrero
Researcher, Computer Engineering Student

Marcus M. Saralde
Researcher, Computer Engineering Student

Michael John P. Pabanil
Researcher, Computer Engineering Student

Approved by:

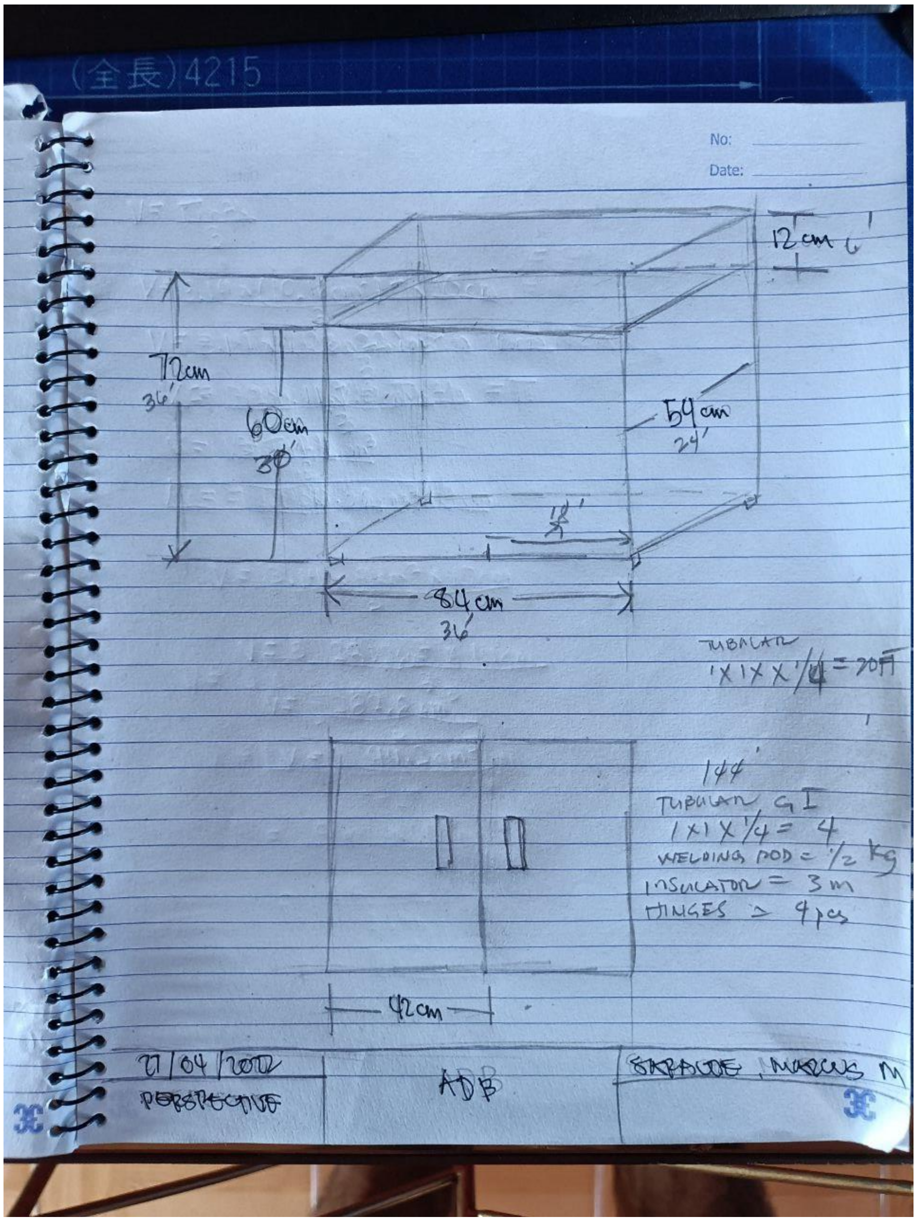
Engineer Pedrito M. Tenerife Jr.
Adviser, Computer Engineering Practice and Design 1

Noted by:

Engineer Julius S. Cansino
Chairperson, Computer Engineering

Appendix 4

PLANNED DIMENSIONS



Appendix 5

LIKERT SCALE FOR SOP 3A-3B

SATISFACTION

1. HOW SATISFIED WERE YOU WITH USING THE DEVICE?
    1) VERY DISSATISFIED.
    2) SOMEWHAT DISSATISFIED.
    3) NEITHER SATISFIED NOR DISSATISFIED.
    4) SOMEWHAT SATISFIED.
    5) VERY SATISFIED.

2. HOW WELL DOES THIS PRODUCT MEET YOUR NEEDS?
    1) IT DID NOT MEET MY NEEDS AT ALL.
    2) IT MET VERY FEW OF MY NEEDS.
    3) IT MET SOME OF MY NEEDS.
    4) IT MET THE MAJORITY OF MY NEEDS.
    5) IT MET ALL OF MY NEEDS.

LOW COST

1. ON A SCALE OF 1 TO 5, HOW REASONABLY PRICED DO YOU THINK THIS PRODUCT IS COMPARED TO OTHER SIMILAR PRODUCTS?

    1) THIS PRODUCT IS NOT A REASONABLY PRICE AT ALL.
    2) THIS PRODUCT IS A SLIGHTLY REASONABLE PRICE.
    3) THIS PRODUCT IS A MODERATELY REASONABLE PRICE.
    4) THIS PRODUCT IS A VERY REASONABLY PRICE.
    5) THIS PRODUCT IS AN EXTREMELY REASONABLY PRICE.

2. ON A SCALE OF 1 TO 5, DO YOU THINK THIS PRODUCT IS GOOD VALUE FOR MONEY?

    1) I DO NOT THINK THIS PRODUCT IS GOOD VALUE FOR MONEY AT ALL.
    2) I THINK THIS PRODUCT IS SLIGHTLY GOOD VALUE FOR MONEY.
    3) I THINK THIS PRODUCT IS MODERATELY GOOD VALUE FOR MONEY.
    4) I THINK THIS PRODUCT IS VERY GOOD VALUE FOR MONEY.
    5) I THINK THIS PRODUCT IS EXTREMELY GOOD VALUE FOR MONEY.

Source Code

Bill of Materials/Costing Correspondence

Instrument Transcription (if applicable)

Certification of Originality Check

Resume

Necessary documents