ARDUINO-BASED PLASTIC BOTTLE CONVERSION INTO POINTS TO DUTY HOURS IN CITY COLLEGE OF TAGAYTAY

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Chapter I

INTRODUCTION

Arduino is an electronics platform freely accessible as open-source software and hardware. It bridges the gap between the real and virtual worlds, providing a helpful way to develop project ideas. Arduino is commonly used in industry for prototyping and can control devices like sensors and motors. Arduino Integrated Development Environment (IDE) is the software used to write and upload code to the Arduino board. The Arduino programming language is based on C/C++. With the help of the powerful and affordable Arduino device, anyone can build a variety of electronic projects and prototypes.

Using Arduino technology, researchers can create new ways for recycling and managing plastic bottles. Plastic Bottles Converting Machine (PBCM) is a type of machine that accepts used or empty plastic bottle containers and converts them into duty hours for students using an Arduino-based system. By integrating Arduino microcontrollers with sensors and other electronics, this prototype can detect and count bottles based on their size. Arduino-based systems provide a solution for tackling environmental issues like plastic bottle waste.

As per the Dean of the Office of Student Empowerment and Support (OSES), one of the concerns in the institution is the large amount of litter from plastic bottles littered around campus, which is not properly processed for recycling. Students often leave their plastic bottles in classrooms, hallways, and on the school grounds. To solve this issue, one solution could be to introduce converting points into duty hours for collecting plastic bottles. This would reduce waste and clean up the campus by decreasing the number of plastic bottles left lying around. According to Mariya (2020), the generation of waste is on the rise while landfill space is becoming scarce, making recycling a crucial method for effective waste management. A significant portion of this waste consists of plastic discarded after use. To address this, we plan to develop a Reverse Vending Machine that collects plastic bottles and provides rewards.

Students often leave their plastic bottles in classrooms, hallways, and on the school grounds. The main problem at City College of Tagaytay is the large amount of litter from plastic bottles littered around campus, which is not properly disposed of for recycling. Plastic bottles contribute significantly to environmental pollution because of their long-term decomposition to break down and are often thrown away improperly, causing pollution. In terms of fulfilling duty hours, some students may be unwilling or may lack sufficient time to participate in regular cleaning activities. To address this issue, a potential solution is to implement a system that allows students to convert collected plastic bottles into equivalent duty hours. This initiative not only encourages student participation but also contributes to reducing the accumulation of plastic waste on campus.

Considering the aforementioned statements, the researchers propose a study entitled Arduino-Based Plastic Bottles Conversion into Points to Duty Hours in City College of

Tagaytay. This study aims to implement a system that converts collected plastic bottles into equivalent duty hour points, thereby addressing two primary concerns: reducing plastic bottle litter within the campus and assisting students in fulfilling their required duty hours. The initiative specifically targets the reduction of plastic waste generated from areas such as the CCT's "White House", promotes a culture of recycling, and provides tangible benefits to students. To facilitate this program, a recycling station will be strategically placed in a highly visible and accessible location on campus to encourage active participation. This research benefits the environment, engages students in recycling, and demonstrates how technology can address real-world issues. This research offers a more convenient alternative for students who may be unwilling or lack sufficient time to perform traditional cleaning duties. It provides a structured system for the proper collection of plastic bottles in exchange for duty hours, while also encouraging students of City College of Tagaytay to participate more actively in environmental sustainability efforts through plastic bottle collection.

Objective of the Study

The main objective of the study is to develop the Arduino-based Plastic Bottles Conversion into Points to Duty Hours in City College of Tagaytay, which will be able to count the points of plastic bottles and convert them into duty hours, as well as properly store those bottles in City College of Tagaytay.

Specifically, it aims to:

1. identify the requirements needed for the development of an Arduino-based solution through data gathering, observation, and interviews within the organization.

2. analyze the gathered requirements needed for the development of the prototype through the use of the Theoretical Framework, Conceptual Diagram, Context Diagram, and Use Case Diagram.

3. design and develop an Arduino-based prototype called Arduino-Based Plastic Bottle Conversion into Points to Duty Hours, which is capable of;

a) allowing the student to input their student number;

b) counting and converting deposited plastic bottles into corresponding duty hour points, with real-time display on an LCD screen;

c) providing students instructions to properly deposit plastic bottles categorized by size, such as 290ml to 500ml and 1 liter to 1.5 liters.

4. fabricate the prototype that is capable of;

a) accepting plastic bottles deposited by students;

b) detecting and rejecting non-plastic bottles/materials;

c) converting deposited plastic bottles, categorized into 290ml to 500ml and 1 Liter to 1.5 Liters, into equivalent duty hour points;

d) and printing a record of the converted duty hours.

5. formulate a plan for the implementation of the plastic bottle's conversion into points to duty hours using Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay;

6. test the performance of the prototype through unit testing, integration testing, and acceptance testing, ensuring compliance with ISO 9126 standards; and,

7. prepare an implementation plan for the deployment of the prototype is inside the campus in City College of Tagaytay.

Scope and Limitations of the Study

The study focuses on developing an Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay to reduce waste in campus and collect recyclable plastic bottles. The prototype is designed to convert all plastic bottles deposited by students into points, which can be redeemed as duty hours through the Office of Student Engagement and Services (OSES). The system is intended for a single type of user, specifically referred to in this study as the 'student'.

Students who deposit plastic bottles into the prototype will earn points. The plastic bottles should be deposited in the prototype with the bottle cap facing the user. Each student is allotted a maximum of two (2) duty hours per term—Prelim, Midterm, and Finals—resulting in a total of six (6) hours per semester. This limitation is implemented to prevent excessive use of the prototype and to ensure that students continue to uphold cleanliness responsibilities within the campus. If a student exceeds the two-hour limit per term, the prototype will continue to accept plastic bottles; however, the Office of Student Engagement and Services (OSES) reserves the right to decide whether the excess hours will be credited to the next term or grading period. This prototype is exclusively intended for use by students, as they are required to fulfill specific duty hour requirements.

The study is composed of four (4) modules: Student ID Module, Recognition Module, Counting Module, and Print Module.

Student ID Module: In this module, the LCD Panel of the prototype will display where the student is required to input their student number before they deposit a plastic bottle.

Recognition Module: This module will identify if a plastic bottle is deposited. If it is a plastic bottle, then it will be accepted. If the object is not a plastic bottle, such as a metal or glass bottle, the prototype will reject it. The weight sensor will measure the weight of deposited plastic bottle, if the plastic bottle exceeds to the measure that sets into 3 grams for 290ml to 500ml, the prototype will reject it, and if the plastic bottle exceeds to the measure that sets into 13 grams for 1Liter to 1.5Liters, the prototype will reject it. In addition, the module is equipped with a buzzer that will be activated once the sensor detects that the container has reached its maximum capacity. This serves as a notification that the prototype is full and the accumulated plastic bottles need to be removed.

Counting Module: This module will count the plastic bottles that the student deposited as points. Each type of plastic bottle has an equivalent time. For 1 Liter to 1.5 Liters, each piece is equivalent to 1 point, converted into 3 minutes. For 290ml to 500ml, each piece is equivalent to 1 point, converted into 1 minute.

Print Module: This module allows students to print and view a ticket containing their transaction record. The ticket includes the student number, accumulated points for small bottles (290ml to 500ml) and large bottles (1 liter to 1.5 liters), the equivalent converted duty hours, the date and time of the transaction, and a designated area for the OSES faculty signature.

However, the study is limited in offering specific features and functions. The Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay is only applicable to students in CCT. Additionally, only plastic bottles are accepted; hence, metal, glass, and other non-plastic bottle materials are not allowed. Moreover, the buzzer will be triggered once the sensor detects that the storage bin is full,

indicating that the accumulated plastic bottles need to be removed. At this point, the prototype will no longer accept additional plastic bottles until the contents are cleared. Furthermore, this prototype does not automate the collection of plastic bottles, the student must manually deposit plastic bottles, while the prototype only converts the points into duty hours credited each deposit. The prototype does not have a database or transaction history, and also does not have segregation inside, and only accepts empty plastic bottles. Since this is still a prototype, it is sensitive to its components and has a weight detector that only allows lightweight 3g (grams) plastic bottles. OSES has the right to manage the conversion of duty hours. This means that they are authorized to check the record and approve the duty hours earned from the prototype.

Significance of the Study

The study, titled Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay, aims to collect plastic bottles by converting them into points that can be redeemed for duty hours. The prototype is designed to cater to specific students, in collaboration with the Office of Student Empowerment and Support. It will provide significant benefits to the following individuals:

City College of Tagaytay. This study will be able to prepare ways to diminish plastic bottles in the school to be able to produce clean surroundings. It will also be important to the school in the future because it aims to provide ways to create effective programs to implement waste management among its students.

Office of Student Empowerment and Support (OSES). This prototype will help OSES to manage the students efficiently, and without doing much manual labor. The

prototype facilitates plastic waste collection, allowing OSES to better support recycling efforts and work together on waste management plans.

Students. Through this prototype, the students will be able to minimize their duty hours by collecting used bottles around the school. The significance of this prototype to the students is to be used as an awareness and solution to reduce plastic bottles inside the school. Through this initiative, students will also gain an understanding of proper waste management practices.

Researchers. It provides various information about waste management that can help students gain knowledge about the field and develop an interest in studying it to further waste disposal innovation.

Future Researchers. This research will provide additional information and data to future researchers who will research within the same category, specifically on the use of machines to develop innovations in the field of waste management. Future researchers may also assess the end product of this research to further understand and use it as a reference for conducting their study.

Theoretical Framework

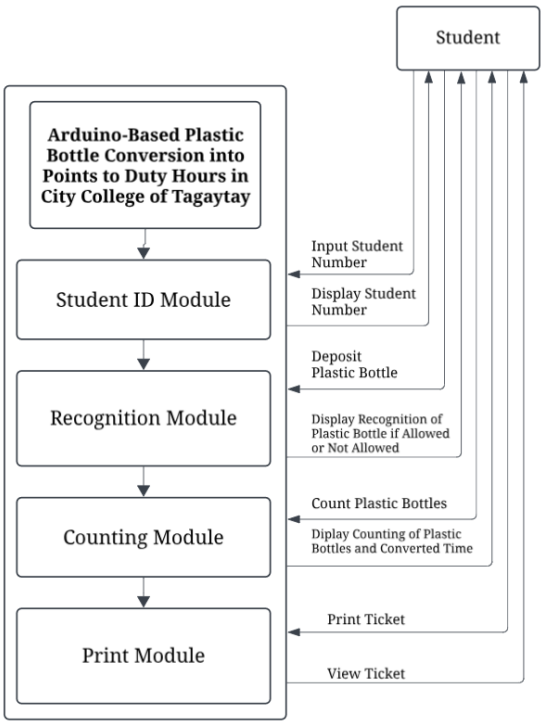

Figure 1. Theoretical Framework of Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay

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Print Module: In this module, students can print and view their transaction details on a ticket. The ticket includes the student number, points earned for both small (290ml to 500ml) and large (1 Liter to 1.5 Liters) plastic bottles, total converted time, date and time, and the signature of the OSES faculty. The researchers used a ticket to print the transaction, because this prototype does not have a database or transaction history.

Conceptual Model of the Study

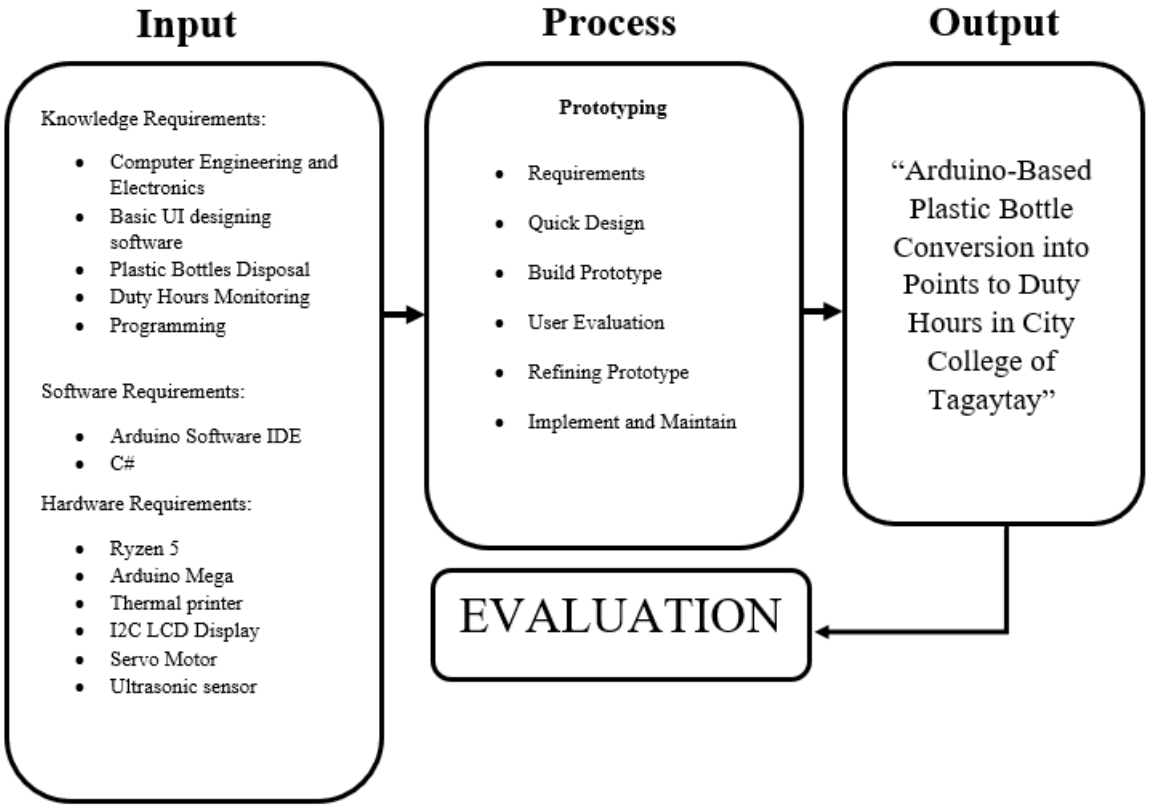

Figure 2. Conceptual Model of Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay

Figure 2 shows the Conceptual Model of Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay. It has four (4) stages consisting of Input, Process, Output, and Evaluation. This must be integrated with a common purpose to achieve the main objective of this research.

The **Input Stage** is composed of three (3) categories, namely Knowledge Requirements, Software Requirements, and Hardware Requirements.

Knowledge Requirements are basic information used to make decisions and understand ideas. The data gathered helps researchers understand the background information in Computer Engineering and Electronics, Basic UI Designing Software,

Plastic Bottles Disposal, Duty Hours Monitoring, and Programming. Computer Engineering and Electronics are interconnected in Arduino projects, as Computer Engineering involves programming and system design, while Electronics focuses on creating and connecting the hardware components. Basic UI designing software related to Arduino allows the researchers to create simple interfaces for controlling and monitoring Arduino projects. Plastic Bottles Disposal can be improved with Arduino by using sensors and automation to sort, compress, or monitor plastic bottles for recycling. As IT students, acquiring a foundational understanding of programming is essential for the successful development and implementation of such projects.

In Software Requirements, a specific application is required, such as Arduino Software IDE. The study used Arduino Software IDE and C# Programming Language for coding the Arduino.

The hardware requirements refer to the necessary desktop computer resources needed to support the software components of the system. These include the Ryzen 5 processor, Arduino Mega, I2C LCD Display, Servo Motor, and Ultrasonic Sensor. At City College of Tagaytay (CCT), the Duty Hours Monitoring system is implemented, where each student is required to complete a specified number of duty hours. As CCT is a public institution with a student body consisting entirely of scholars, fulfilling this duty hour requirement is a mandatory part of their academic obligations.

The **Process Stage** has the Prototyping Methodology, which includes six (6) phases: Requirements, Quick Design, Build Prototype, User Evaluation, Refining Prototype, and Implement and Maintain. For the Requirements phase, the researchers needed to collect all the requirements to understand how the prototype will work. During

the quick design phase, an initial design must be developed to provide a conceptual representation of the prototype's appearance. Meanwhile, the Build Prototype phase is implemented by assembling the materials and making the necessary connections once the design is complete. In the User Evaluation phase, following the completion of the prototype construction, the system must undergo testing and be presented for evaluation. In the Refining Prototype phase, improvements were made based on the feedback received during the evaluation. Once all phases are completed, the process transitions to the final phase, Implement and Maintain. This phase allowed the researchers to refine the prototype incrementally, using feedback to enhance its functionality and performance. The iterative process helps break down tasks into manageable steps, enabling better monitoring of progress and ensuring continuous improvements.

The **Output Stage** includes the output developed by the researcher, specifically the Arduino-Based Conversion of Plastic Bottles into Duty Hours at City College of Tagaytay. This prototype helps reduce plastic bottle waste on campus by converting them into points that are convertible to duty hours.

The **Evaluation Stage** involved testing the prototype to make sure it meets all requirements, including performance, acceptance testing, and ISO 9126 assessment. Its purpose is to check if the prototype meets all the requirements.

Operational Definition of Terms

Conversion - it means turning collected plastic bottles into duty hours for students. In general, it can also mean changing measurements, changing learning materials into a different format.

Duty Hours - refer to a type of community service or required task that students must complete as part of their school responsibilities. These hours are often necessary for students to fulfill certain requirements before they can get their clearance forms signed. This concept is prevalent in many educational institutions as a way to encourage students to engage with their community, develop a sense of responsibility, and enhance their personal growth.

Points - refer to the numerical value assigned to each deposited plastic bottle based on its type and size. These points serve as a reward system that can be accumulated and later converted into duty hours for students.

Student Number – refers to the unique identifier required by the prototype for validation purposes. It ensures the accurate recording of the student's information on the ticket and facilitates proper validation for the redemption of duty hours.

Ticket - given to students as proof of their collected plastic bottles, which they can use to convert into duty hours.

Chapter II

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter reviews related literature and studies, summarizing research by other scholars. It explains the ideas, both theoretical and conceptual framework that is relevant to this research, and the definition of terms for a better understanding of the prototype.

Table 1 shows the relationship between different types of plastic bottles, the number of points collected, and the corresponding converted time that can be earned.

Table 1. Plastic Bottle Duty Hour Conversion Table.

TYPE OF PLASTIC BOTTLES	POINTS	CONVERTED TIME
1L TO 1.5 L	1	3mins
290ML TO 500ML	1	1min

Based on an interview conducted with the owner of a local junk shop and Mr. Emerson Laurel, the Dean of the Office of Student Extension Services (OSES), the researchers gathered data regarding the weight-to-piece ratio of plastic bottles. According to Dean Laurel, approximately 20 pieces of 1-liter to 1.5-liter plastic bottles are equivalent to one kilogram, while 60 pieces of 290ml to 500ml bottles also constitute one kilogram. Furthermore, Mr. Laurel proposed a conversion system for the study: each 290ml to 500ml plastic bottle is equivalent to one point, which translates to one minute of duty hours. In contrast, each 1-liter to 1.5-liter plastic bottle is likewise equivalent to one point, but corresponds to three minutes of duty hours.

Review of Related Literature

Arduino

Arduino is an Italian open-source hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for creating digital devices.

Arduino IDE

Arduino IDE is an open-source IDE that allows users to write code and upload it to any Arduino board. Written in Java, Arduino IDE is compatible with Windows, macOS, and Linux operating systems.

Arduino MEGA

Arduino MEGA is a microcontroller board built around the ATmega2560. The board features 54 digital input/output pins, 14 of which can be used as PWM outputs, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

Arduino microcontrollers

These are small, versatile electronic devices based on open-source hardware and software platforms, designed to make it easy for users to create interactive projects. These microcontrollers come with a programmable circuit board (microcontroller) and an integrated development environment (IDE) for writing, compiling, and uploading code. Arduino boards are equipped with digital and analog input/output pins, which can be connected to various sensors, actuators, and other components, allowing users to build projects ranging from simple LED displays to complex robotics. They are widely used in

education, hobbyist projects, and prototyping due to their user-friendly design, extensive community support, and affordability.

Duty Hours

Duty hours refer to a form of institutional service that students are required to complete as part of their academic responsibilities. These hours are typically a prerequisite for securing clearance forms, which are essential for enrollment or graduation processes. This practice is commonly implemented in various educational institutions to promote student engagement, instill a sense of accountability, and contribute to their holistic development through community-oriented tasks.

Plastic bottles

These types of bottles are made from polyethylene terephthalate (PET), a type of plastic commonly used for packaging beverages like water, soft drinks, and juices. PET is a strong, lightweight, and transparent material that is both shatter-resistant and capable of preserving the contents' freshness. These bottles are popular because they are recyclable, meaning they can be collected, processed, and reused to create new PET products, which helps reduce environmental impact and conserve resources. PET bottles are widely accepted in recycling programs.

C#

It is a programming language for communicating with and controlling Arduino hardware. Arduino is a popular open-source platform for building electronics projects, typically programmed using its own language (based on C/C++). However, by combining C# with Arduino, a user can create more advanced desktop or web applications that interact with Arduino boards.

Reverse Vending Machine

A Reverse Vending Machine (RVM) is a device that helps collect used bottles and cans for recycling. Unlike regular vending machines that dispense products, an RVM accepts empty containers and rewards the user, often with money, coupons, or points. These machines are commonly used in places like supermarkets, schools, and public spaces to encourage people to recycle. The RVM scans the item to check if it is recyclable, and once accepted, the user gets a reward.

Local Studies

Plastic2Fantastic: Reverse Vending Machine for Plastic Bottles (2024)

Waste has become one of the most pressing global issues today. Recycling is a crucial method for managing waste properly. The Reverse Vending Machine is an innovative concept designed to encourage the habit of recycling waste materials. To address the waste problem, Plastic2Fantastic: Reverse Vending Machine for Plastic Bottles was developed. This machine accepts empty plastic beverage containers and dispenses money in return. Constructed from aluminum, the machine is implemented within a standard trash bin and equipped with a Raspberry Pi 3B, a 7-inch Touch Screen LCD, an RFID reader, a coin hopper, an ultrasonic sensor, a capacitive proximity sensor, an inductive proximity sensor, an IR proximity sensor, and an M995sg servo motor. The machine can detect RFID cards, identify plastic bottles, and dispense coins. Functionality testing demonstrated excellent performance, with a recommendation to add labels for better user guidance. Evaluation results indicated that respondents strongly agreed with the machine's usefulness, highlighting its potential to promote recycling practices. The positive

feedback underscores the machine's effectiveness and user-friendliness, offering a cost-effective and straightforward solution to the waste problem (Baribad et al., 2024).

Development of a System for Converting Recyclable Materials into Virtual Points (2023)

The study aimed to create a system that converts recyclable materials like PET bottles, paper, and metal containers into virtual rewards called RAMCoins. These RAMCoins can be used for various purposes. The system uses an object detection module with a custom dataset that includes PET bottles, paper, and soda cans as trash. It is divided into three parts: detecting trash, weighing it, and handling transactions. After surveying Asia Pacific College students and testing the project, the system showed some minor malfunctions, revealing common issues typically found in such systems (Stanley et al., 2023).

Development of Small-Scale PETE Plastic Bottle Shredder with Electronic Sensor Controls for Cap Separation: Basis for Reverse Vending Machine (2022)

Plastic waste management has long been a challenge in the Philippines. Recent studies indicate that plastic waste frequently pollutes water bodies due to improper handling and disposal. Among these wastes, plastic bottles made from Polyethylene Terephthalate (PETE) are prevalent. To address this issue, this study proposes a novel approach to managing plastic bottle waste using a shredder. This device not only reduces the volume of solid waste, thereby optimizing storage space, but also introduces new recycling methods for plastic. The shredder is equipped with electronic controls to separate caps from bottles prior to shredding, as the caps are made from different plastic materials.

Various sizes of PETE bottles were tested, with 300 to 500 mL bottles achieving an average volume reduction of 50-65% post-shredding. Bottles sized 300-400 mL demonstrated a high shredding success rate of approximately 92%, while the cap detection feature achieved an average accuracy of 88%. The study concludes that this project has successfully developed a small-scale PETE plastic bottle shredder suitable for use in reverse vending machines (Cervantes et al., 2022).

Development of a PET Bottle Collection System for a Green Campus Community (2021)

Waste recycling is crucial for achieving a Green Campus community, with plastic bottle recycling being a particularly impactful method. Researchers developed a PET Bottle Collection System, comprising a Reverse Vending Machine (RVM) prototype and a cross-platform mobile monitoring application, to encourage recycling and proper waste disposal at Iloilo State College of Fisheries, supporting the college's Green Campus initiative. The RVM is capable of distinguishing between plastic and non-plastic bottles using a capacitive proximity sensor and a photoelectric sensor, and it dispenses a one-peso coin for every four plastic bottles accepted. The machine uses a Raspberry Pi 3 Model B+ as its central control unit, an MCP3008 ADC IC to read analog signals from the sensors, and an infrared sensor to detect when the storage capacity is full and ready for extraction. The cross-platform mobile application, built with the React Native framework, monitors the number of coins remaining in the machine, the number of plastic bottles collected, and the RVM's status, indicating whether it is full. The system was tested for functionality, accuracy, efficiency, and response time, and the results demonstrated that it met the

intended design criteria. Further improvements were recommended for implementation in larger environments (Padios et al., 2021).

Design and Development of a Semi-Automated Plastic Bottle and Plastic Waste (2021)

The purpose of this research is to design a semi-automated machine for faster and easier production of Ecobricks using polyethylene terephthalate (PET) 1.5L bottles and polypropylene/polyethylene sachets as fillers. The insertion of the PET bottle into its machine holder and recapping of the produced ecobricks are done manually. The machine used the shredding and compacting mechanisms that are controlled by the developed program using the Arduino. It has a load sensor and a limit switch that serve as the triggering devices for notification. Based on tests and evaluation, the machine attained 100% functionality and 86.67% reliability. The machine provides no significant difference between the weight of the produced ecobricks and the manual process, based on the Mann-Whitney U value, and with a significant difference when it comes to the time of production based on an Independent samples t-test. The designed machine proves that it is functional when it comes to shredding, compacting, and weighing processes. It is reliable in producing the ecobricks for two (2) to five (5) continuous working hours and accurate by providing a minimum of 525 grams of fillers to the PET bottle. It is efficient and convenient to use when it comes to the operating hours as compared to the manual process (Santos et al., 2021).

Reverse Vending Machine with Power Output for Mobile Devices using Vision–Based System (2021)

Polyethylene Terephthalate (PET) bottles are widely used for beverages and food containers, but the majority are not recycled. This study focuses on improving the recycling process for PET bottles using image processing to verify that the bottles are recyclable. The YOLOv3 framework was employed for image training due to its high speed and accuracy. A camera captures an image of the bottle, which is then sent to a Raspberry Pi for classification. If the bottle meets the recycling criteria, a signal activates a DC motor to open the recycling platform. An LCD screen displays the type of bottle and its equivalent recycling time. The study achieved a 90% accuracy rate with a 10% error rate and a device response time of 10.966 seconds. Consequently, the research supports the use of reverse vending machines as a viable recycling solution. (Lopez et al., November 2021).

VENDOBIN: An IoT-based Plastic Bottle Waste Disposal Vending Machine (2020)

Since 2010, environmental protection has become increasingly critical. In the Philippines, approximately 35,580 tons of waste are generated daily, with each person contributing around 0.5 kg of garbage in urban areas and 0.3 kg in rural areas. This study aims to address plastic waste by offering usable products, such as ballpoint pens and bundles of newsprint, in exchange for disposed plastic bottles. The VendoBin combines a garbage bin with a vending machine, designed to encourage proper disposal of plastic bottles through a rewards system. Developed using a Raspberry Pi 3 to control its components, VendoBin uses infrared sensors to distinguish between plastic bottles and non-plastic items, and ultrasonic sensors to monitor whether the bin is full. Users earn points for each transaction, which are recorded in a text file database. Each user, new or

returning, receives a unique code to redeem the usable items. When the VendoBin reaches its capacity, it sends a text message to the relevant authorities for disposal. The VendoBin successfully classified 100% of plastic bottles from non-plastic items and generated codes for both new and returning users (Dacay et al., 2020).

A Feasibility Study of a Modified Deposit-Based Return System for PET and other Recyclable Bottles and Containers (2020)

The demand and supply for PET in Cagayan de Oro City are growing at an annual rate of 3.1 percent, with per capita consumption increasing from 8.4 kg in 2020 to 9.5 kg in 2025. Supply calculations are based on total off and on-trade sales, multiplied by 91.5 percent, minus the demand from 2020 to 2025. Bottled water leads beverage sales, followed by carbonated drinks. Consumers appreciate PET bottled drinks for their design, size, shape, durability, customer service, delivery responsiveness, cost competitiveness, and ability to meet specific needs. In terms of supply, the preferred features are recyclability, cost-effectiveness, suitability for packaging, design versatility, and customization options. The PET bottle market share averages 28 percent, surpassing the average supply of 18 percent. A household survey indicated that a deposit return system (DRS) for managing empty PET bottles is generally acceptable, with retailers and manufacturers managing a centralized system that uses reverse vending machines to ensure bottles are returned for recycling and consumer deposits are refunded. While there are 12 PET recycling companies in the Philippines, they were not included in the survey, as the study focused on the market, financial, and management feasibility of establishing the system. However, including them in a comprehensive feasibility study is recommended. Implementing the proposed DRS for the city is estimated to take 19 months. A contingency

plan was not included, as the proposed DRS requires enabling laws from the executive branch of the government, with local retailers, manufacturers, and consumers guided by implementing rules and guidelines. Therefore, the contingency plan is on hold (Paurom, 2020).

Aluminum can to WiFi trading system with metal can and plastic bottle collector and monitoring system. (2020)

Over the decades, the price of aluminum has consistently risen due to global economic factors. Despite this, many people tend to overlook that aluminum scrap is recyclable and valuable. In response, the authors have developed a machine that functions as a recycling bin. By identifying the problem, they established objectives to guide the creation of the "Aluminum Can to WiFi Trading System with Metal Can and Plastic Bottle Collector and Monitoring System" for the school. This machine features a ramp and specific dimensions to serve as a pathway for collected metal cans and plastic bottles, with separate bins for each material. It is equipped with ultrasonic, inductive, and infrared sensors to sort, monitor, and count the items. Information, terms, conditions, and transaction details are displayed on a TFT LCD screen with three push buttons for user input. Additionally, the machine includes an Access Point acting as the Network Address Translator to provide internet access to users. This project is based on a microcontroller and incorporates various microelectronics devices, including an Ultrasonic Sensor (HCSR04), a TFT LCD Display (MD070SD), an IR proximity sensor, NPN Inductive Sensor (LJ12A3-4-Z/BX NPN), MG996R Servo, SG90 Micro Servo, ESP8266 node MCU, Arduino MEGA, and push buttons. These components have been meticulously programmed and tested to ensure proper functionality. The authors have developed an

aluminum trading device with robotic applications, featuring an access point, monitoring capabilities, and sorting mechanisms for metal cans and plastic bottles. Through careful design, data collection, and reliability testing, they demonstrated that the system is effective and will help the school manage the plastic bottles and metal cans used by students. (Panganiban et al., 2020).

Bottle-SegreDuino: An Arduino Frequency-Based Bin for Tin Can and Plastic Bottle Segregation using an Inductive Proximity Effect (2020)

In the current scenario, waste disposal has become a major problem owing to increasing urbanization, industrial activities, and growth in the human population. The world's volume of solid waste produced is gradually increasing; inadequate recycling and improper disposal of solid waste are a source of water, land, and air contamination, and present risks to human health and the atmosphere. Currently, policy in all countries is working on innovative approaches to tackling the problems posed by solid waste management (SWM). Various methods have been developed and utilized for effective solid waste disposal and segregation. Through an inductive proximity sensor and an ultrasonic proximity sensor, this paper aims to separate a tin can from a plastic bottle. Ultrasonic proximity sensor transmits ultrasonic waves to sense the target's presence or absence. This is connected to the inductive proximity sensor, which is connected to a microcontroller to separate metals from plastics to process the data of each object. The device includes an inductive proximity sensor that is used to detect metallic objects without any contact. When the object reaches the sensor, the current flow of induction decreases, particularly on metals, as it has higher frequencies than plastic. The study was conducted with a total evaluation accuracy of 94% (Dioses Jr., 2020).

Design and Implementation of Automated Waste Segregator with Smart Compression (2020)

This study, entitled "Design and Implementation of Automated Trash Bin with Smart Compression", aims to design and implement an efficient system that will help to properly segregate waste. Two Arduino Unos are interconnected to each other, along with all the components needed to achieve the desired output. Push buttons are used to determine what kind of waste is going to be disposed of. LEDs were used to indicate if the input is correct. The Stepper Motor is responsible for the rotation of the trash bins that are attached to a circular metal plate. An ultrasonic sensor was used to determine if paper or plastic bins need to be compressed. Compression was made possible using a Linear Actuator, leading to maximized space for the trash bin. LEDs will also serve as an indicator that the bins are already full. It will help the Local Government Units and the community in obtaining a greener environment and aiding the problem of solid waste management in this country. (Endaya et al., 2020).

Foreign Studies

Turning Trash into Treasure: Developing an Intelligent Bin for Plastic Bottle Recycling (2024)

Plastic pollution has become a significant global issue due to its persistent nature and the limited options for recycling. Addressing this challenge, this paper introduces a Detection-Based Reward System (DBRS) and a novel business model to enhance plastic waste management, reduce plastic waste in the environment, and promote cleanliness. By leveraging the YOLOv5 algorithm, known for its high accuracy, speed, and open-source availability, the system excels in plastic bottle detection. Users can easily enroll in the

system, initiating an automated detection process that calculates reward points based on the plastic bottles they deposit. These points are stored in a centralized database. The system's comprehensive design also includes a robust business model aimed at increasing participation in waste disposal practices, contributing to Sustainable Development Goals (SDGs) for a healthier environment. Remarkably, the DBRS achieves state-of-the-art performance in plastic bottle detection, with a mean Average Precision (mAP) of 0.973, highlighting its effectiveness in addressing plastic pollution. (Munira et al., 2024).

Design for an Intelligent Waste Classifying System: A Case Study of Plastic Bottles (2023)

The widespread use of plastic bottles has raised significant environmental concerns, making their recycling a priority. Small and medium-sized recycling companies often need to collect and categorize large quantities of plastic bottles before selling them to larger recycling firms. This process is typically time-consuming, costly, and labor-intensive, with the manual sorting posing health risks, particularly during the COVID-19 pandemic, and affecting worker productivity. To address these challenges, this study proposes developing an automated conveyor belt system capable of quickly and accurately separating plastic bottles by type. The system employs a platform that distinguishes between opaque and transparent plastic bottles, thereby saving time, reducing costs, and minimizing manpower requirements. This design offers recycling SMEs a competitive edge by serving as a practical application model and prototype with an easy-to-use concept. Key tools used in this research include product design development (PDD), Kansei engineering, manufacturing process design, control systems, and fault tree analysis (FTA). Light sensors play a critical role in the separation process by detecting the opacity or transparency of

bottle surfaces. The proposed prototype's reliability will be evaluated using FTA, which considers all potential failures. This study enhances the knowledge base on integrating conveyor systems and provides valuable insights for businesses looking to optimize their sorting processes. The guidelines developed can serve as a foundation for further research on incorporating conveyors into waste sorting facilities (Rianmora et al., 2023).

Easy Conversion of PET Bottles to Eco-Filament for 3D Printing and Process Characterization (2023)

Due to the economic and ecological impact, material recycling technologies are increasingly privileged and preferred over standard processes. This article focuses on the potential to recover polyethylene terephthalate (PET) from water and soft drink bottles that have been poorly stored, transported, and used, as well as from bottles from different manufacturers. The process used is to convert the bottle into a 1.75 mm diameter filament without fragmentation or dissolving. It does not require any heavy or industrial equipment and can be easily made even by 3D printing enthusiasts. The study then used an FDM (Fused Deposition Modeling) 3D printer to build the modeled shape using the resulting filament. The results of the process were characterized (tensile strength and hardness) and compared with those of 3D printing with “polylactic acid” (PLA), the most commonly used material in this type of printing. It offers adequate properties for many applications (close mechanical properties: elasticity around 230 MPa, maximum mechanical strength around 29 MPa, hardness around 10 MPa) (Aissa et al., May 2023).

Smart Dustbin Reverse Vending Reward Machine (2023)

Today, with the increasing amount of garbage produced and the limited availability of land for disposal, effective waste management strategies are crucial. Environmental awareness has become a significant trend and an essential aspect of modern society. The study's initiative aims to transform behavior by encouraging people to dispose of trash properly rather than littering. The reward bin will generate points based on the waste deposited and convert them into coupons. The user's ID barcode is scanned using a barcode scanner in this intelligent reward container, which stores the user's information in a database. To dispose of the waste, a servo motor activates, opening the dust bin. An IR sensor detects the waste in the bin. Users will receive discounts via mail or text message to their mobile phones based on the waste they have deposited. The researchers believe this approach could make a small but impactful difference, potentially changing people's perspectives and encouraging them to use trash cans properly (Pagare et al., 2023).

Collection of plastic bottles by reverse vending machine using object detection technique (2023)

A reverse vending machine (RVM) operates in the opposite manner of a traditional vending machine, accepting used water and soft drink bottles. It verifies whether the bottles are plastic using object detection techniques based on pre-trained models. Once identified, the bottles are transported into the machine via a conveyor belt. In this approach, detection and training are performed using a Haar cascade classifier. While sensors such as photoelectric sensors, IR spectrometers, and barcode readers can make the machine expensive, modern object detection technology helps reduce costs compared to traditional methods. In the digital payment era, customers receive rewards for their bottles in the form

of coupons sent to their email or via SMS. The GUI allows users to choose between email and SMS and enter their details. The collected bottles are then sent to recycling facilities (Yaddanapudi et al., 2023).

Integration of a Reverse Vending Machine Sensing System in Sorting and Detecting Plastic Bottle Waste (2023)

A reverse vending machine (RVM) is a device designed to accept garbage, such as used plastic bottles, and provide rewards when fed into the system one unit at a time. The system utilizes several components, including the load cell sensor module HX711, light-dependent resistor (LDR) sensor, ultrasonic sensor HCSR04, and the Arduino Mega 2560 microcontroller. The aim of this study is to design an embedded system that can identify plastic bottle waste based on volume, transparency, and weight. The study involves integrating various parts of the plastic bottle detection system into a cohesive unit and comparing the test results with previous research on plastic bottle detection. The Plastic Bottle Garbage Detection System implemented in the RVM demonstrated a detection accuracy of up to 95.33%. This was based on testing 33 sample plastic bottles of various sizes, ranging from 160 to 1500 ml, with different quantities per sample. Each sample was tested up to 30 times to determine the number of successful detections. These improved detection results are expected to serve as a benchmark for future development of plastic bottle waste detection systems using straightforward components, contributing significantly to the field of sensing systems and electronics education (Juansah & Rahmawati, October 2023).

Design and implementation of incentive-based smart plastic bottle disposal system (2023)

This project presents a comprehensive solution to address the growing environmental concerns associated with plastic waste. Through image processing and machine learning algorithms, the system accurately identifies plastic bottles, facilitating their proper disposal. By integrating microcontrollers and motors, this system encourages responsible disposal practices among users by automating the detection and categorization of plastic bottles into respective trash compartments. IoT technology records the weight of the plastic bottle, associating it with the user as virtual currency in the cloud. Users are incentivized through this rewards system, which they can conveniently track via a mobile application. The reward points can be redeemed for various benefits, promoting sustainability. Real-time data tracking and IoT integration further enhance the efficiency of the system. At its core, this innovative system seeks to revolutionize the way users interact with plastic waste, fostering a cleaner, greener, and more conscientious society (Rahman et al., 2023).

Reverse Vending Machine Using TCRT5000 and Inductive Proximity Sensors for Bottles and Cans Sorting (2023)

Garbage has long been an issue in Indonesia, largely due to a lack of interest in proper disposal and inadequate waste management. In response, a Reverse Vending Machine (RVM) was designed to address this problem by detecting bottles and cans and offering rewards for proper disposal. The machine utilizes a TCRT5000 sensor to identify bottles and an inductive proximity sensor to detect cans. Both types of waste are automatically sorted into designated bins, and the rewards are calculated based on the total number of bottles and cans deposited. A push button allows users to print a reward ticket,

which is only issued if bottles or cans have been deposited. Additionally, ultrasonic sensors monitor the trash bins, and LEDs notify users if the bins for bottles or cans are full. After 24 tests, the machine achieved a 100% success rate (Simatupang, December 2022).

Reverse Vending Machine for Plastic Bottle Recycling (2020)

In the 21st century, the increasing volume of waste combined with limited landfill space has made recycling a crucial method for effective waste management. A significant portion of this waste consists of plastic, which is often discarded after use. The goal is to develop a Reverse Vending Machine (RVM) designed to collect plastic bottles and offer rewards. The system will use image processing technology to identify plastic bottles. After the bottles are counted, depositors can claim points by entering a unique ID, which can then be used to generate promo codes for online shopping. Both users and authorities can track their information through an application software. When the machine at a specific location is full, the authority will be notified via messaging through the application. (Mariya et al., 2020).

An automated plastic bottle collection system (2020)

Improper disposal of refuse has, in recent times, caused harm to lives and properties. In local cities and towns, it is common to find waste in inappropriate places such as gutters. This project focuses on the use of the Internet of Things and smart systems to aid the waste management system by providing an automated plastic bottle collection system. This project is focused on providing an efficient method of automating plastic bottle collection by placing value on all bottles. Value is placed on plastic bottles returned

to motivate individuals to recycle; vouchers are generated for each bottle returned. The prototype of the automated plastic bottle collection monitors a number of bottles, bin level, and generates vouchers. Information on the number of bottles and bin level is secured in a web application to determine when bins should be emptied (Amarteifio, 2020).

Chapter III

METHODOLOGY

This chapter discusses the Project Design, Project Methodology using the Prototyping Model, Operation and Testing Procedure, and Evaluation Procedure.

Project Design

This study, entitled Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay, aims to develop a system capable of counting deposited plastic bottles and converting them into equivalent duty hours. Additionally, the system can ensure the proper storage of collected plastic bottles within the campus. The prototype is developed using the Arduino Software IDE and is designed for use exclusively by students, who serve as the primary users of the system.

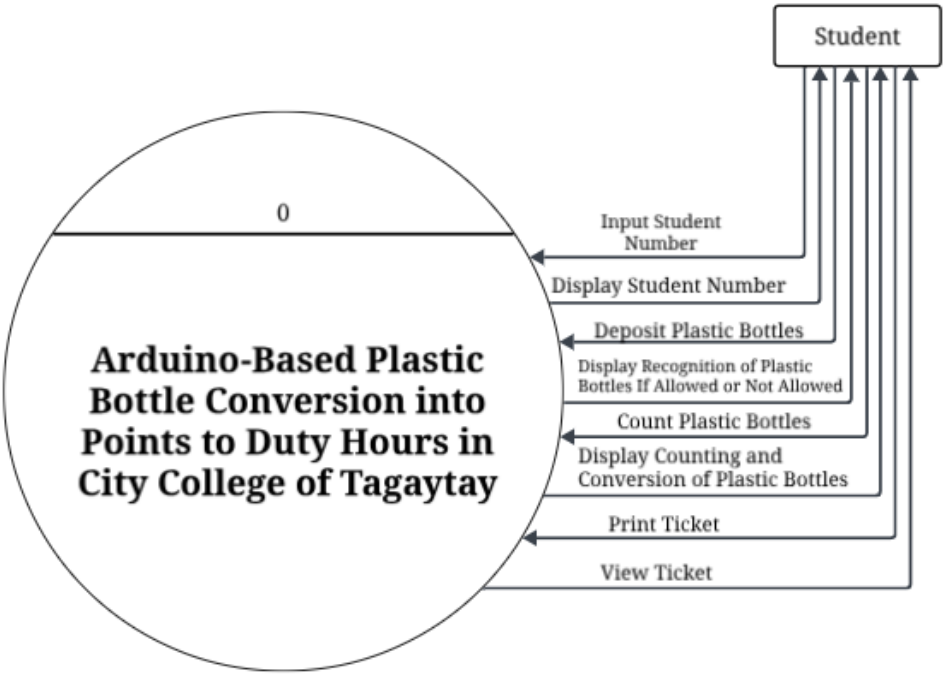

Figure 3. Context Diagram of Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay

Figure 3 illustrates the context diagram that shows one entity, which is the Student. The Student will input their student number into the prototype. The display screen will initially show the student number entered by the user. Once the student number is confirmed, the student may proceed to deposit a plastic bottle into the prototype. The system is equipped with a sensor capable of detecting and verifying whether the item inserted is a plastic bottle. If the deposited item is confirmed to be a plastic bottle, the system will accept it for processing. If the student deposits a non-plastic bottle or any kind of waste except a plastic bottle, the prototype will reject it. After depositing the plastic bottle, the prototype will measure the weight and count the number of plastic bottles deposited, and will display the points earned by the student. The prototype will trigger a buzzer once the sensor detects that the plastic bottles have reached the limit to notify the student that it is full and ready to remove the accumulated plastic bottles inside the prototype. Lastly, when the student is done depositing the plastic bottles, the student will print and view the ticket, including the Student Number, Date and Time, points earned, and the conversion. This will ensure that the process made by the student is correct.

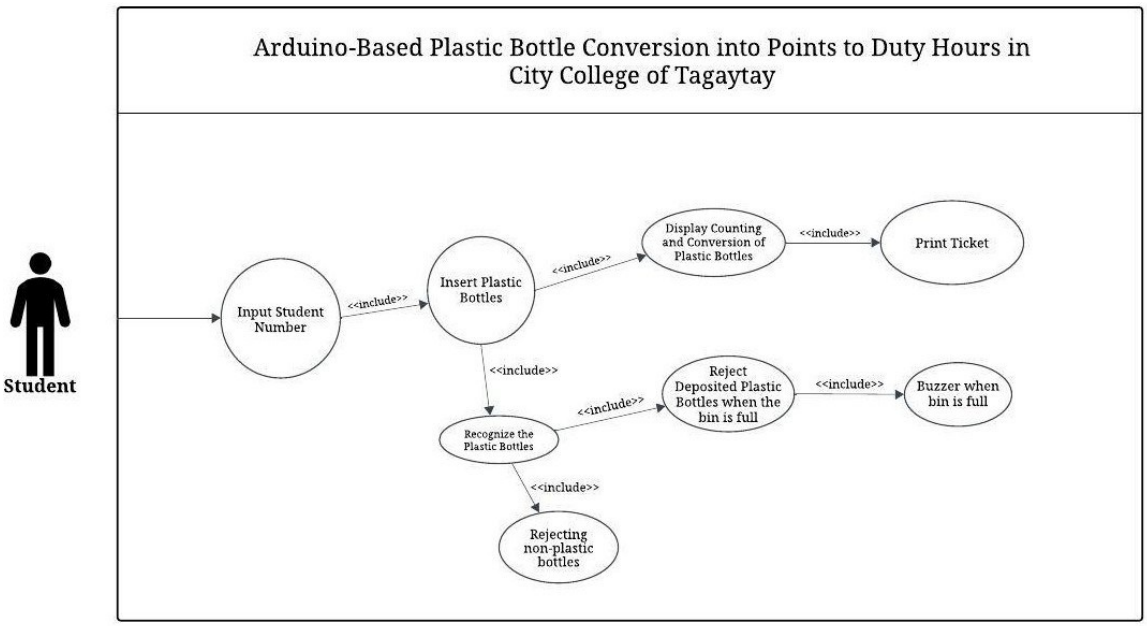

Figure 4. Use Case Diagram of Student

Figure 4 illustrates the Use Case Diagram showing the student's interaction with the prototype. The student will input their student number, so the student can view their student number on the LCD Panel. Subsequently, the student may continue depositing plastic bottles, and the prototype will count the total number of accepted bottles. The system incorporates a mechanism for both accepting valid plastic bottles and rejecting non-compliant items. It is programmed to identify whether the deposited item qualifies as a plastic bottle based on pre-defined parameters. The student will be able to view the real-time count and the corresponding conversion of plastic bottles into points, which are then translated into duty hours. This information is displayed on the LCD panel for transparency and verification. Once the transaction is complete, the student may generate and print a receipt or ticket. The ticket contains key information, including the student number, total points earned, equivalent duty hours, date and time of the transaction, and the signature of

the OSES Faculty for official validation. They can view the printed ticket to ensure that the process made by the student is correct.

Project Methodology

The prototyping model is a development method in which a prototype is created, tested, and refined as necessary until a satisfactory result is achieved. This result serves as the foundation for developing the complete prototype or product. The design is constructed according to the requirements, and a prototype for a specific design is produced and provided to the student. The relevant adjustments are then made depending on the student's feedback.

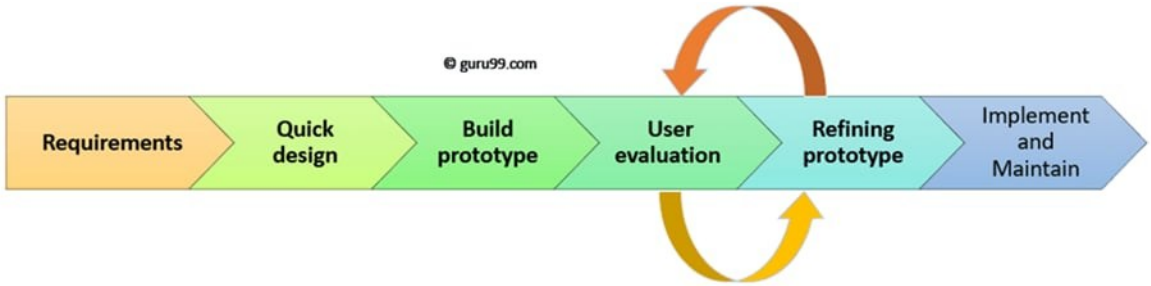

Figure 5. Prototype Methodology (Madhavankutty, 2020)

Requirements

The researchers had a brainstorming meeting to share each other's ideas and knowledge about the project. The researchers conducted an interview with Mr. Emerson Laurel, Dean of OSES, on the process of converting points into duty hours. Conducting research and analysis on the appropriate software and hardware components was essential in guiding the development of the 'Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay' system.

Quick Design

In the second phase, a preliminary or quick design was created. During this stage, a basic design of the prototype was developed. The Design must be created to give an idea of what the prototype would look like. Although it would not be a complete design, it would provide a general overview of the prototype for the student. The researchers used a circuit website to design a quick design diagram of Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay. This quick design helped in the development of the prototype.

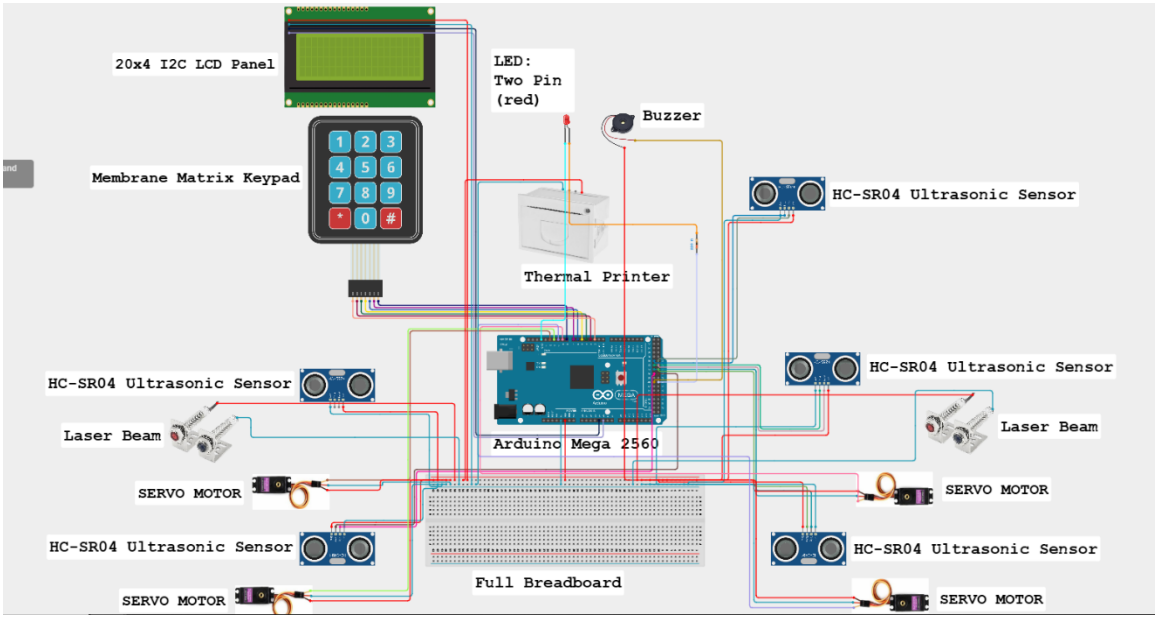

Figure 6. Pictorial Diagram of Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay

As illustrated in Figure 6, the Arduino Mega is utilized due to its increased number of input/output pins and memory capacity, making it suitable for managing multiple sensors, motors, and other components. The 20x4 I2C LCD Display serves to show the student number, the count of deposited plastic bottles, and the corresponding converted duty hours. A Membrane Matrix Keypad is integrated for data entry, such as inputting the

student number. An Ultrasonic Sensor is used to detect the presence of plastic bottles and to keep count of the items deposited. It also determines when the prototype reaches its maximum capacity. In such cases, a Buzzer is activated to notify that the bin is full, and an LED indicator lights up as a visual alert. Servo Motors are employed to control the acceptance or rejection of deposited items based on material type. A Laser Beam Sensor helps distinguish plastic bottles from non-plastic items. Finally, a Thermal Printer is used to print the student's transaction record, which includes the number of deposited plastic bottles, the converted duty hours, the date and time, and the signature of the OSES faculty for verification purposes.

Build Prototype

In this phase, an actual prototype was created using the information gathered from the quick design. The researchers visualized the prototype as a stand-alone system. Part of the prototype had an I2C LCD Display where students were required to input their student number, and it also displayed the counting and conversion of plastic bottles. The prototype included different sensors: a laser beam, which detected rejected objects, transparent plastic bottles, and other deposited items; and an ultrasonic sensor, which detected whether the prototype had reached its capacity and identified objects. A buzzer was activated when the prototype reached its capacity. The prototype also had servo motors for accepting and rejecting plastic bottles. An Arduino Mega 2560 was used to handle more complex tasks, requiring additional pins and memory. The code was arranged using Arduino IDE Software and the C# Programming Language. This resulted in a functional model of the proposed prototype.

User Evaluation

In this stage, the proposed prototype was presented to the students for evaluation. This process helped identify the strengths and weaknesses of the working model. Feedback and suggestions were gathered from the students and then provided to the developer.

Refining Prototype

If the student was dissatisfied with the current prototype, the researchers refined it according to the student's feedback and suggestions. This phase continued until all of the student's specified requirements were met. Once the student was satisfied with the revised prototype, a final prototype was developed based on the approved version.

Implement and Maintain

Once the final prototype, based on the completed prototype, was developed, it underwent extensive testing before being deployed to production. Regular maintenance was then performed to minimize downtime and prevent major failures.

Prototype Operation and Testing Procedure

Operation for the Student:

1. The student inputs their student number.
2. The student deposits a plastic bottle into the prototype.
3. The prototype displays the earned points and the converted time.
4. The prototype prints a ticket once the transaction is completed.
5. The student views the printed ticket.

6. The student proceeds to OSES for further confirmation of claiming the duty hours.

Testing Procedure

After securing all the required hardware and software, the researchers accomplished the following steps to test the prototype:

Unit Testing

Each process module was tested to ensure it could be used for the Prototype. The objective of this test was to verify the functionality of specific sections of code, usually at the function level. The researchers tested each component of the program to demonstrate that each one met its functional and requirement specifications.

Integration Testing

To determine whether the modules functioned properly, the researchers tested every single part of the Prototype. The researchers combined individual modules and tested them collectively to ensure the prototype functioned correctly. This step was important to verify that the modules interacted smoothly and that the entire prototype functioned as designed. Integration testing helped to identify problems such as interface mismatches, errors, and unexpected behaviors that might not have been detected during unit testing. This ensured that the whole prototype functioned properly, leading to a consistent and dependable prototype.

Acceptance Testing

The students evaluated the prototype to confirm that it satisfied their requirements and met the necessary criteria. The goal was to verify that the prototype fulfilled the students' needs and to assess its overall quality.

Evaluation Procedure

The researchers examined all important components necessary for improving and finalizing the Prototype. Respondents were given an ISO9126-compliant evaluation form. The results were analyzed to assess whether the outputs satisfied the students' needs. The comments, suggestions, and recommendations of the respondents were used to develop and enhance the Prototype.

Table 2 shows the numerical rating and its equivalent interpretation to scale the result of the project evaluation.

Table 2. System Evaluation Sheet Numerical and Descriptive Scale.

NUMERICAL RATING	INTERPRETATION	DEFINITION
4.21- 5.00	Excellent	The system fully meets and far exceeds the most expectations.
3.41- 4.20	Very Good	The system fully meets all and exceeds several expectations.
2.61- 3.40	Good	The system fully meets all expectations.
1.81- 2.60	Fair	The system does not fully meet all expectations.
1.00- 1.80	Poor	The system fails to meet expectation to a significant degree in several areas.

Chapter IV

RESULTS AND DISCUSSION

This chapter provides an overview of the prototype, specifically focusing on its Project Description, Project Structure, and Screen Hierarchy.

Project Description

This study, entitled Arduino-Based Plastic Bottles Conversion into Points to Duty Hours in City College of Tagaytay, aims to provide a more convenient alternative for students who may be unwilling or lack the time to perform traditional cleaning duties. It introduces a system for the proper collection of plastic bottles in exchange for duty hours, thereby encouraging students of the City College of Tagaytay to actively participate in recycling efforts. This initiative not only supports environmental sustainability but also promotes student engagement in fulfilling institutional requirements.

The Process Stage of the Prototyping Methodology involves six key phases: Requirements, Quick Design, Build Prototype, User Evaluation, Refining Prototype, and Implement and Maintain. These phases are essential for successfully developing and completing the project. This study used the prototyping method, which involves creating and improving the prototype step by step based on user feedback. Here's how the process worked:

In the Requirements phase, the researchers gathered all the necessary information to understand how the prototype should function. Researchers held a brainstorming session to discuss ideas and determine the best approach. To ensure the system aligned with the school's needs, they interviewed Mr. Emerson Laurel, the Dean of OSES, to learn how

points are converted into duty hours. They also researched the required software and hardware, such as the Arduino board, sensors, and display screens, that would be used to build the prototype.

In the Quick Design phase, the researchers created a basic design of the prototype. This was not the final version, but it served as a prototype sketch to show what the system would look like. They used a circuit diagram website to create a visual diagram of how the components would be connected. This design helped them understand the function of the prototype before actually building it.

In the Build Prototype phase, the researchers gathered all the necessary materials and began constructing the prototype. The prototype was designed to function independently. Several key components were integrated to ensure its functionality. The I2C LCD Display was included to allow students to enter their student number and view the counting and conversion of plastic bottles into points. The Laser Beam Sensor was used to detect rejected objects and transparent plastic bottles, ensuring that only plastic bottles were able to pass. The Ultrasonic Sensor detects an object and is used for the bin when it is full. Additionally, a Buzzer was placed to activate when the bin was full, alerting users that it could not accept plastic bottles. Servo Motors control the acceptance and rejection of plastic bottles based on their detection. The prototype was powered by an Arduino Mega 2560, which served as the main controller, managing all processes and input from the sensors. The coding and programming of the prototype were done using Arduino IDE Software to ensure proper system operation. At the end of this phase, the researchers had successfully built a working model of the prototype.

The User Evaluation phase was conducted once the prototype was built. The researchers tested its functionality and presented it to students to gather feedback. The students interacted with the prototype and found parts that needed fixing. The researchers recorded their suggestions and discussed them with the developer to make a necessary adjustment.

In the Refining Prototype phase, the researchers made modifications to the prototype based on student feedback. If students were not satisfied with certain aspects, adjustments were made accordingly. This process continued until all requirements were met and the students approved the revised prototype. Once the final version was confirmed, it was prepared for full implementation.

The last phase was Implement and Maintain; the final prototype was thoroughly tested to ensure it functioned smoothly before being officially used. To keep it running efficiently, regular maintenance was planned to prevent breakdowns and ensure long-term functionality. This structured process enabled the researchers to develop an effective and user-friendly prototype that successfully converted plastic bottle deposits into points and duty hours for students.

Project Structure

This prototype, named Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay, was developed to count plastic bottles, convert them into equivalent duty hours, and ensure their proper storage within the campus of City College of Tagaytay. It was made using the following hardware materials: Arduino Mega 2560, five (5) Ultrasonic Sensor, four (4) Servo Motors, two (2) Loadcell Amplifier, two (2) Weight Sensor 3kg (kilograms), two (2) Laser Beam, RTC Module, Thermal Printer,

LED Light (red), 20x4 I2C LCD Panel, Membrane Matrix Keypad, Buzzer, Jumper Wires, PWM Servo Driver-PCA9685, DC-DC Buck Converter LM2596S, Power Module, and Extension Cord Socket.

The Prototype is connected to a stable power source through a UPS, which provides continuous Direct Current (DC) power. The prototype's electrical components, including the Arduino Mega 2560 and sensors, are powered through a DC-DC Buck Converter LM2596S for voltage regulation. The hardware components are properly housed within a durable outer casing made of cladding, painted all white for a polished look, and with added protection. The prototype also includes jumper wires to facilitate control, while the thermal printer and LCD panel provide real-time results on transactions. The structured design of the prototype ensures proper counting and conversion of plastic bottles into duty hours while maintaining a secure and functional interface for the users. The bin is designed as drawer drawer-style door for easier collection of accumulated plastic bottles inside the prototype. There is also a door in front and back to secure and manage the electrical system if there is a technical problem with all components.

Screen Hierarchy of the Study

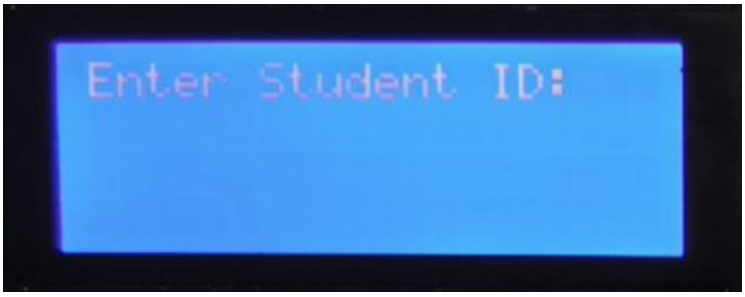

Figure 7. I2C LCD Panel

Figure 7 shows the I2C LCD Panel, which prompts the student to input their student number. This feature ensures accurate recording and tracking of each transaction.

Figure 8. Conversion for 290ml to 500ml and 1L to 1.5L Plastic Bottle

Figure 8 illustrates the conversion process for plastic bottles ranging from 290ml to 500ml and 1L to 1.5L. When a student inserts a 290ml to 500ml plastic bottle, the prototype registers it as 1 point, equivalent to 1 minute of duty credit. For bottles sized 1L to 1.5L, the system similarly records 1 point, which corresponds to 3 minutes of duty credit.

Figure 9. Matrix Membrane Keypad

Figure 9 shows the Matrix Membrane Keypad, which is used for inputting the student number into the prototype. This allows the prototype to accurately record and verify the student's identity before processing their transaction.

Figure 10. Thermal Printer

Figure 10 shows the Thermal Printer, which is used in the prototype to print transaction receipts after a student deposits a plastic bottle. Once the student successfully inputs their student number and the prototype processes the conversion, the printer generates a ticket showing the total points and corresponding minutes or hours earned.

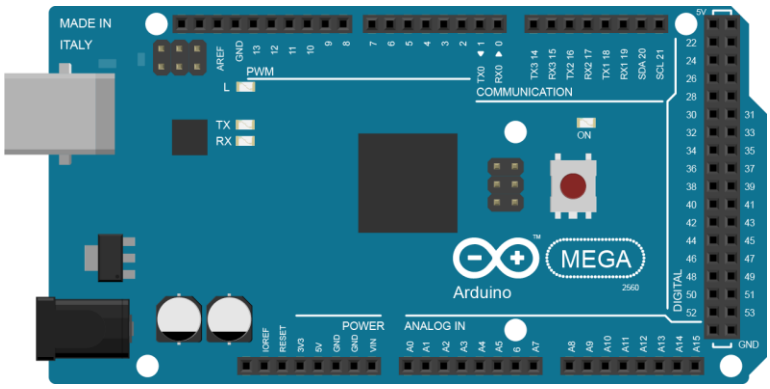

Figure 11. Arduino Mega 2560

Figure 11 shows the Arduino Mega 2560 - the prototype that effectively automates the recognition of plastic bottles and converts them into points that contribute to students' duty hours at City College of Tagaytay.

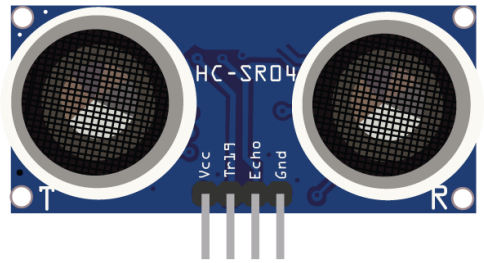

Figure 12. HC-SR04 Ultrasonic Sensor

Figure 12 shows the HC-SR04 Ultrasonic Sensor, which is responsible for detecting plastic bottles and counting each one deposited. Additionally, the sensor determines when the prototype has reached its maximum capacity.

Figure 13. Servo Motor

Figure 13 shows the Servo Motor, which is used to handle the acceptance or rejection of the deposited plastic bottles, determining if they will be allowed or not allowed into the prototype.

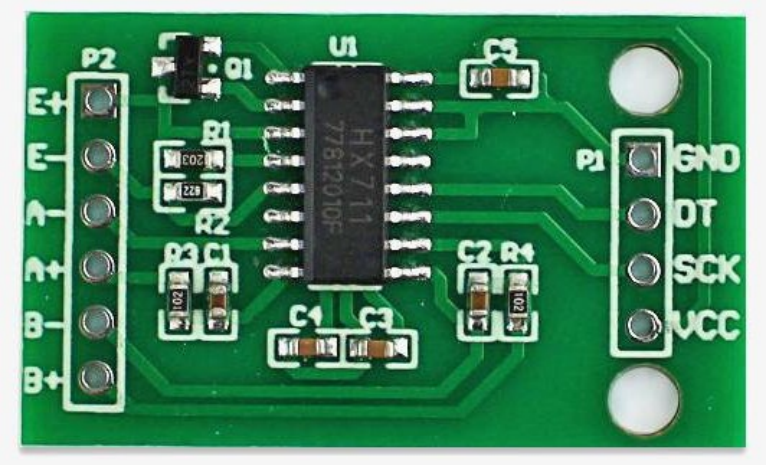

Figure 14. Loadcell Amplifier

Figure 14 shows the Loadcell Amplifier, which is used to amplify and convert the small electrical signals from the weight sensor into readable data, allowing the Arduino Mega 2560 to accurately measure the weight of plastic bottles for proper classification and point conversion. Also, it is used to control and set the weight required in the prototype.

Figure 15. Weight Sensor 3kg (kilograms)

Figure 15 shows the Weight Sensor 3kg (kilograms), which works together with the Load Cell Amplifier to accurately measure the weight of deposited plastic bottles. The maximum weight accepted is 3kg.

Figure 16. Laser Beam

Figure 16 shows the Laser Beam used to detect plastic bottles by sending a light beam to a receiver. If the Laser blocks the receiver, the prototype will not accept the plastic bottles; only empty plastic bottles and transparent plastic bottles are allowed to be accepted.

Figure 17. RTC Module

Figure 17 shows the RTC Module used to record the exact time and date of each student transaction, ensuring an accurate record of conversion and printed ticket.

Figure 18. LED Light (red)

Figure 18 shows the red LED light, which functions as a warning indicator to notify users when the prototype bin is full and requires the removal of the accumulated plastic bottles. The LED is positioned at the front of the prototype for easy visibility.

Figure 19. Buzzer

Figure 19 shows the Buzzer, which serves as a warning indicator to alert users that the prototype has reached its capacity.

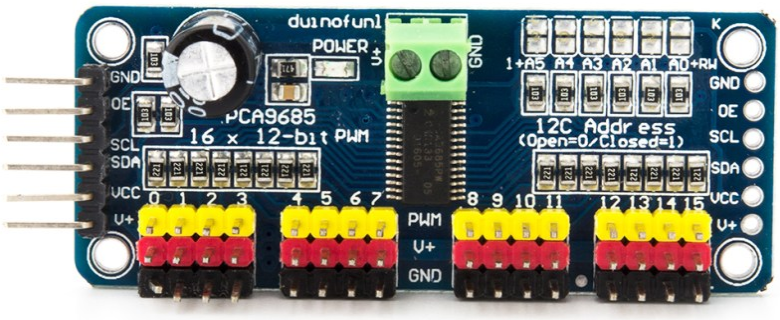

Figure 20. PWM Servo Driver-PCA9685

Figure 20 illustrates the PWM Servo Driver-PCA9685, which is utilized to control and manage up to fifteen (15) multiple servo motors, enhancing the prototype's efficiency and automation. However, in this specific prototype, only four servo motors are connected.

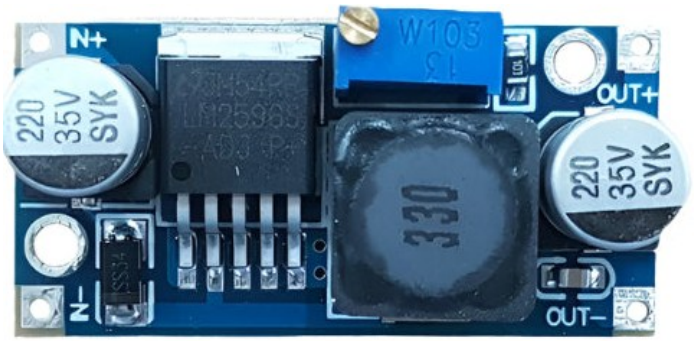

Figure 21. DC-DC Buck Converter LM2596S

Figure 21 shows the DC-DC Buck Converter LM2596S used to reduce a high voltage to a lower, stable voltage needed by the prototype.

Figure 22. Power Module

Figure 22 shows the Power Module used to supply and distribute electricity to the different components inside the prototype.

Figure 23. Mini UPS

Figure 23 shows the Mini UPS used to provide backup power during electrical outages or fluctuations. It ensures that small electronic devices like routers, modems, security cameras, and mini-computers continue running temporarily when the main power supply is lost.

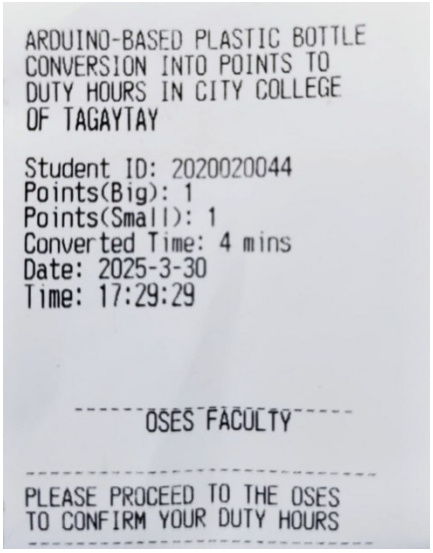

Figure 24. Ticket

Figure 23 illustrates the ticket used to redeem duty hours at the OSES. The ticket includes the title of the prototype, student number, points earned, converted time, date and time, and the OSES faculty signature for verification in order to claim the duty hours.

Project Evaluation

The researchers evaluated the developed prototype using the ISO 9126 standards, focusing on six categories: Functionality, Aesthetic, Workability, Durability, Economy, and Safety. Functionality ensures that the prototype performs correctly and serves its intended purpose. Aesthetic examines its user-friendly design and visual appeal to attract users. Workability assesses whether the prototype functions effectively and provides benefits to users. Durability checks the quality of materials and design to determine if it is strong or easily breakable. Economy considers the overall cost, including materials, labor, and additional hardware needed for improvements. Lastly, Safety ensures that the prototype protects users from potential risks such as electric shocks, sharp edges, and fire hazards.

Evaluation Results

Breakdown of the Respondents

The researchers used Raosoft Inc.'s sample size calculator to determine the sample size using a 5% margin of error, 95% confidence level, and a 50% response distribution. The sample size of the students is two hundred eighty-three (283), among which twenty-three (23) is the sample size for the Client/Instructors, and five (5) for the IT professionals.

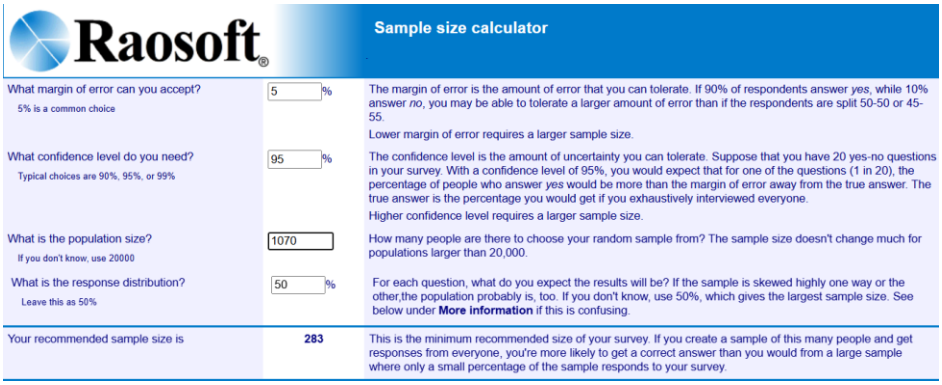

Figure 25. Raosoft Sample Size Calculator for Students at the School of Computer Studies (SCS) of City College of Tagaytay

Figure 25 shows the computation for the sample size of students at the School of Computer Studies (SCS) of City College of Tagaytay. The total population of students is 1,070, and based on the Raosoft Sample Size Calculator, the recommended sample size is 283.

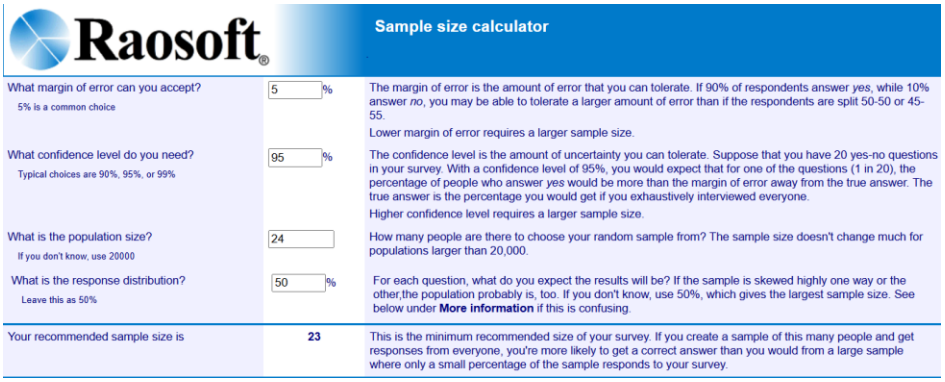

Figure 26. Raosoft Sample Size Calculator for Instructors at the School of Computer Studies (SCS) of City College of Tagaytay

Figure 26 shows the computation for the sample size of instructors at the School of Computer Studies (SCS) of City College of Tagaytay. The total population of instructors is 24, and based on the Raosoft Sample Size Calculator, the recommended sample size is 23.

Table 3 shows the breakdown of the respondents who evaluated the prototype using the ISO 9126 standard. 90.71% or 283 of the total respondents are from the students, 8.33% or 23 are from the instructors, and 0.96% or 5 are from IT professionals.

Table 3. Breakdown of the Respondents

CLASSIFICATION	NUMBER	PERCENTAGE
Students	283	90.71%
Client/ Instructors	23	8.33%
IT Professionals	5	0.96%
Total	**311**	**100.00%**

Respondents' Assessment of the Functionality Criteria

Table 4 presents the respondents' evaluation results for the project's Functionality criteria. The prototype received a mean score of 4.51, which is classified as "Excellent". This means the prototype fully meets and even exceeds most expectations.

Table 4. Functionality Criteria Assessment of Hardware

INDICATORS	MEAN	INTERPRETATION
Completeness	4.49	Excellent
Accuracy	4.46	Excellent
Data Acquisition	4.57	Excellent
MEAN AVERAGE	**4.51**	**Excellent**

Scale:

4.21-5.00 Excellent
3.41-4.20 Very Good
2.61-3.40 Good
1.81-2.60 Fair
1.00-1.80 Poor

Respondents' Assessment of the Aesthetic Criteria

Table 5 presents the respondents' evaluation results for the project's Aesthetic criteria. The prototype received a mean score of 4.48, which is classified as "Excellent". This means the prototype fully meets and even exceeds most expectations.

Table 5. Aesthetic Criteria Assessment of Hardware

INDICATORS	MEAN	INTERPRETATION
Size is appropriate	4.47	Excellent
Design	4.55	Excellent
Modular	4.41	Excellent
MEAN AVERAGE	**4.48**	**Excellent**

Scale:

4.21-5.00 Excellent
3.41-4.20 Very Good
2.61-3.40 Good
1.81-2.60 Fair
1.00-1.80 Poor

Respondents' Assessment of the Workability Criteria

Table 6 presents the respondents' evaluation results for the project's Workability criteria. The prototype received a mean score of 4.41, which is classified as "Excellent". This means the prototype fully meets and even exceeds most expectations.

Table 6. Workability Criteria Assessment of Hardware

INDICATORS	MEAN	INTERPRETATION
Availability of materials	4.34	Excellent
Technical Expertise	4.46	Excellent
Availability of Data Sheet	4.44	Excellent
MEAN AVERAGE	**4.41**	**Excellent**

Scale:

4.21-5.00 Excellent
3.41-4.20 Very Good
2.61-3.40 Good
1.81-2.60 Fair
1.00-1.80 Poor

Respondents' Assessment of the Durability Criteria

Table 7 presents the respondents' evaluation results for the project's Durability criteria. The prototype received a mean score of 4.40, which is classified as "Excellent". This means the prototype fully meets and even exceeds most expectations.

Table 7. Durability Criteria Assessment of Hardware

INDICATORS	MEAN	INTERPRETATION
Quality of Materials	4.4	Excellent
Quality of Workmanship	4.44	Excellent
Quality of Design	4.37	Excellent
MEAN AVERAGE	**4.40**	**Excellent**

Scale:

4.21-5.00 Excellent
3.41-4.20 Very Good
2.61-3.40 Good
1.81-2.60 Fair
1.00-1.80 Poor

Respondents' Assessment of the Economy Criteria

Table 8 presents the respondents' evaluation results for the project's Economy criteria. The prototype received a mean score of 4.44, which is classified as "Excellent". This means the prototype fully meets and even exceeds most expectations.

Table 8. Economy Criteria Assessment of Hardware

INDICATORS	MEAN	INTERPRETATION
Economy of Materials	4.41	Excellent
Economy of Time and Labor	4.46	Excellent
Economy of Machines	4.46	Excellent
MEAN AVERAGE	**4.44**	**Excellent**

Scale:

4.21-5.00 Excellent
3.41-4.20 Very Good
2.61-3.40 Good
1.81-2.60 Fair
1.00-1.80 Poor

Respondents' Assessment of the Safety Criteria

Table 9 presents the respondents' evaluation results for the project's Safety criteria. The prototype received a mean score of 4.42, which is classified as "Excellent". This means the prototype fully meets and even exceeds most expectations.

Table 9. Safety Criteria Assessment of Hardware

INDICATORS	MEAN	INTERPRETATION
Absence of Sharp Edges	4.28	Excellent
Provision for protection	4.44	Excellent
Safety from electrical shock	4.55	Excellent
MEAN AVERAGE	**4.42**	**Excellent**

Scale:

4.21-5.00 Excellent
3.41-4.20 Very Good
2.61-3.40 Good
1.81-2.60 Fair
1.00-1.80 Poor

Respondents' Overall Assessment of the Hardware

Table 10 shows the overall evaluation results of the prototype. It achieved a mean average score of 4.44, which is interpreted as "Excellent", indicating that the prototype not only fully meets but also greatly exceeds most expectations.

Table 10. Overall Assessment for the Hardware

INDICATORS	MEAN	INTERPRETATION
Functionality	4.50	Excellent
Aesthetic	4.48	Excellent
Workability	4.41	Excellent
Durability	4.40	Excellent
Economy	4.44	Excellent
Safety	4.42	Excellent
MEAN AVERAGE	**4.44**	**Excellent**

Scale:

4.21-5.00 Excellent
3.41-4.20 Very Good
2.61-3.40 Good
1.81-2.60 Fair
1.00-1.80 Poor

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The findings, conclusions, and recommendations gathered from the evaluation's outcome are included in this section.

Summary

The study focused on the development of an Arduino-based system for converting plastic bottles into points that can be redeemed as duty hours at City College of Tagaytay. The system is designed to count and convert the plastic bottles into duty hours while ensuring proper storage of the collected bottles within the college premises.

This prototype can aid the Office of Student Empowerment and Support (OSES) in managing students more efficiently, reducing manual tasks, and streamlining the process at City College of Tagaytay. The study aims to reduce plastic bottle waste in the school, contributing to a cleaner environment. It can also be valuable for the school in the future, as it focuses on creating effective programs to promote waste management among students.

The prototype is powered by a stable source through a UPS, ensuring a continuous supply of Direct Current (DC) power. Its electrical components, including the Arduino Mega 2560 and sensors, receive regulated voltage through a DC-DC Buck Converter LM2596S. All hardware components are securely enclosed in a durable cladding case, painted white for a polished look and added protection. The prototype utilizes jumper wires for control, while a thermal printer and LCD panel display real-time transaction results. The well-structured design enables accurate counting and conversion of plastic bottles into

duty hours while maintaining security and ease of use. The bin features a drawer-style door for convenient collection of accumulated plastic bottles. Additionally, front and back access doors allow for secure management and troubleshooting of electrical components when technical issues arise.

The researchers' development used prototyping methodology and focused on six categories, namely Requirements Gathering and Analysis, Quick Design, Build Prototype, User Evaluation, Refining Prototype, and Implement and Maintain.

The evaluation for the students, clients/instructors, and IT professionals was carefully based on ISO 9126, including Functionality, Aesthetics, Workability, Durability, Economy, and Safety. The assessment involved all of the students from City College of Tagaytay. The evaluation respondents consist of two hundred eighty-three (283) students, twenty-three (23) are the sample size of the instructors, and five (5) are for IT professionals.

The final evaluation resulted in an average score of 4.44, classified as "Excellent". The highest rating was in Functionality, demonstrating that the prototype effectively performed its intended purpose and met user expectations.

Conclusions

In conclusion, the Arduino-Based Plastic Bottle Conversion System at City College of Tagaytay successfully meets its goal of counting the points of plastic bottles and converting them into duty hours. The system accurately counts the plastic bottles, assigns points, and ensures proper storage of the collected bottles. The prototype is designed to benefit specific students, including those under the Office of Student Empowerment and Support. Overall, this project provides an efficient and secure way to manage plastic bottle

collection and makes the process easy to use. It also serves as a useful reference for future projects that aim to combine technology with waste management and sustainability.

The researchers used the Prototyping Methodology, where they created a sample model, tested it, and improved it until they obtained a good result. This final version became the basis for making the complete product. The design was made based on the requirements, and a sample was given to the student. Changes were then made according to the students' feedback.

The evaluation of the prototype was conducted among students, instructors, and IT professionals, following the ISO 9126 standard, which assesses hardware quality based on six characteristics: Functionality, Aesthetics, Workability, Durability, Economy, and Safety. The assessment included all students from City College of Tagaytay, with a total of two hundred eighty-three (283) respondents, along with a sample size of twenty-three (23) instructors and five (5) IT professionals. Feedback from these groups resulted in an overall rating of "Excellent". Among the evaluated characteristics, Functionality received the highest rating, reflecting the evaluators' satisfaction with the prototype's performance and potential.

This study aims to achieve its primary objective of counting plastic bottles and converting them into duty hours while ensuring proper storage at City College of Tagaytay. Additionally, it seeks to reduce plastic bottle waste on campus by implementing a prototype that allows students to collect bottles and exchange them for points, which can be redeemed for duty hours. The prototype is specifically designed to benefit students, including those under the Office of Student Empowerment and Support (OSES).

Recommendations

The following recommendations are proposed for the future development of the Arduino-Based Plastic Bottles Conversion into Points to Duty Hours in City College of Tagaytay:

1. Add other recyclable materials, like scratch paper, that can accept by the prototype.
2. Add a login form for the OSES and users.
3. Add a database for recording data.
4. Add a segregator inside the prototype that separates the large and small plastic bottles.

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APPENDICES

Appendix A. Summary of Evaluation

Indicators	IT Professionals	Client/Instructors	Students	Mean Average	Descriptive Rating
FUNCTIONALITY					
Completeness	4.8	3.87	4.80	4.49	EXCELLENT
Accuracy	4.8	3.78	4.79	4.46	EXCELLENT
Data Acquisition	5	3.91	4.79	4.57	EXCELLENT
Average:				**4.50**	**EXCELLENT**
AESTHETIC					
Size is Appropriate	4.6	4.13	4.67	4.47	EXCELLENT
Design	5	3.96	4.69	4.55	EXCELLENT
Modular	4.6	3.96	4.67	4.41	EXCELLENT
Average:				**4.48**	**EXCELLENT**
WORKABILITY					
Availability of Materials	4.4	3.91	4.69	4.34	EXCELLENT
Technical Expertise	4.8	3.87	4.70	4.46	EXCELLENT
Availability of Data Sheet	4.8	3.78	4.74	4.44	EXCELLENT
Average:				**4.41**	**EXCELLENT**
DURABILITY					
Quality of Materials	4.4	4.04	4.74	4.40	EXCELLENT
Quality of Workmanship	4.6	3.96	4.77	4.44	EXCELLENT
Quality of Design	4.4	3.96	4.74	4.37	EXCELLENT
Average:				**4.40**	**EXCELLENT**
ECONOMY					
Economy of Materials	4.4	4	4.82	4.40	EXCELLENT
Economy of Time and Labor	4.8	3.83	4.76	4.46	EXCELLENT
Economy of Machine	4.6	4	4.77	4.46	EXCELLENT
Average:				**4.44**	**EXCELLENT**
SAFETY					
Absence of Sharp Edges	4.8	3.83	4.60	4.28	EXCELLENT
Provision for Protection	4.4	3.83	4.69	4.44	EXCELLENT
Safety from Electrical Shock	5	3.91	4.75	4.55	EXCELLENT
Average:				**4.42**	**EXCELLENT**
OVERALL MEAN AVERAGE:				**4.44**	**EXCELLENT**

Appendix B. Sample Evaluation Instrument

CCT_SCS - Form 8

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
Akle St., Kaybagal South, Tagaytay City 4120
Tel. Nos. (046) 483-0470 / (046) 483 -0672

SCHOOL OF COMPUTER STUDIES

EVALUATION INSTRUMENT FOR HARDWARE (ISO 9126)

Title: **ARDUINO-BASED PLASTIC BOTTLE CONVERSION INTO POINTS TO DUTY HOURS IN CITY COLLEGE OF TAGAYTAY**

Proponents: **Renzo Symon T. Baral, Daniel T. Cadacio Jr., Clark Jude S. Caretas, Michaela R. Castillo, Erika Roseann S. Florentino**

Evaluator Name: _____

Type of Evaluator: **IT Professional** ☐ **Client/Instructor** ☐ **Student** ☐

Instruction: Please kindly evaluate the software material by using the given scale and placing a checkmark (✓) under the corresponding numerical rating.

NUMERICAL RATING	INTERPRETATION	DEFINITION
5	Excellent	The system fully meets and far exceeds the most expectations.
4	Very Good	The system fully meets all and exceeds several expectations.
3	Good	The system fully meets all expectations.
2	Fair	The system does not fully meet all expectations.
1	Poor	The system fails to meet expectation to a significant degree in several areas.

INDICATORS	5	4	3	2	1
A. FUNCTIONALITY					
1. The microcontroller, devices and electronics devices function the specified task.					
2. The microcontroller, devices and electronics devices yield correct and precise data.					
3. The microcontroller, devices and electronics devices serve as data acquisition devices, measurement devices, data analyzer/interpreter and visualizer.					

B. AESTHETIC					
1. The size of prototype materials is appropriate.					
2. The design of prototype materials used are conforming to the form factor standard.					
3. The prototype kit is modular.					
C. WORKABILITY					
1. The materials and components of prototype are available and can be easily purchased.					
2. The technical expertise and support are available.					
3. The data sheets of the components and devices are available.					
D. DURABILITY					
1. The quality of materials/components used for prototype.					
2. The quality of workmanship done in developing prototype.					
3. The quality of design of develop prototype.					
E. ECONOMY					
1. Economy in terms of materials needed.					
2. Economy in terms of time/labor spent.					
3. Economy in terms of machines required.					
F. SAFETY					
1. Absence of sharp edges.					
2. Provision for protection devices.					
3. The prototype components/materials are safe from electrical shock.					

- *Based on ISO 9126*

Findings:

1. _____
2. _____
3. _____

Recommendations:

1. _____
2. _____
3. _____

_____
Signature

Appendix C. Letters/Approval Sheet

Republic of the Philippines
City of Tagaytay
City College of Tagaytay
Akle St., Kaybagal South, Tagaytay City 4120

BAGONG PILIPINAS

CERTIFICATION OF ENGLISH CRITIQUE

This is to certify that the undersigned has read, reviewed, and edited the thesis/capstone project, *ARDUINO-BASED PLASTIC BOTTLE CONVERSION INTO POINTS TO DUTY HOURS IN CITY COLLEGE OF TAGAYTAY* by **BARAL, RENZO SYMON T., CADACIO, DANIEL T. JR., CARETAS, CLARK JUDE S., CASTILLO, MICHAELA R.,** and **FLORENTINO, ERIKA ROSEANN S.**

This further certifies that the scope of editing is within only the technical preparation and grammatical evaluation of the manuscript.

JEFF JEREMIAH C. PEREA, MA, LPT
License No. 1418168
English Critic
City College of Tagaytay

Republic of the Philippines
PROFESSIONAL REGULATION COMMISSION
PROFESSIONAL IDENTIFICATION CARD

LAST NAME	PEREA
FIRST NAME	JEFF JEREMIAH
MIDDLE NAME	CELESTINO
REGISTRATION NO.	1418168
REGISTRATION DATE	12/22/2015
VALID UNTIL	03/22/2027

PROFESSIONAL TEACHER

23

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CERTIFICATION

23-6996853

This is to certify that the person whose name, photograph, and signature appear herein is a duly registered professional, legally authorized to practice his/her profession with all the rights and privileges appurtenant thereto.

This is to certify further that he/she is a professional in good standing and that his/her certificate of registration/professional license has not been suspended, revoked or withdrawn.

Signature of Professional

CHARITO A. ZAMORA
Chairperson

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
Akle St., Kaybagal South, Tagaytay City 4120
Tel. Nos. (046) 483-0470 / (046) 483-0672

Dear Professor/s,

Good Day!

We are third-year students currently enrolled in the Bachelor of Science in Information Technology program. As part of our academic requirement for the Methods of Research course (MERE1), we are conducting interviews.

The focus of our proposed capstone project is the "Development of Arduino-Based System for Converting Plastic Bottles into Points to Duty Hours in City College of Tagaytay". These questions are designed to gather insights from you regarding your expectations, preferences, and requirements for the M-Learning application. Your input will help us customize the solution to effectively meet your needs.

We kindly request your consent to participate as one of our respondents in this interview. Please note that your responses will be used solely for academic purposes and will be treated with strict confidentiality under the Data Privacy Act of 2012 (RA 10173).

Thank you very much for considering our request for participation in the interview and for your valuable time and support.

Sincerely,

Baral, Renzo Symon
Researchers

Cadacio, Daniel Jr.
Researchers

Cañetas, Clark Jude
Researchers

Castillo, Michaela
Researchers

Florentino, Erika Roseann
Researchers

Mr. Angelito Caraan
Capstone Advisor

MS. FLORENCE R. MANALO
Research Coordinator

(signature over printed name)

July 9, 2024
EMERSON LAUREL
DEAN, OSES

Quetionaires:

1. *What is the common problem about trash?*
2. *What are things that are recyclable materials that can be sellable?*
3. *Why do recyclable materials need to be sold?*
4. *How many bottles are needed to have 1hr duty?*
5. *How many kilos of bottles are needed to have duty hours?*
6. *Is it necessary that different bottles are needed to convert to duty hours?*
7. *Is it possible to just base it on counting the bottles?*
8. *If there is a system, who can take bottles from the system?*
9. *Where can the bottle points earned by the student be redeemed in the system?*
10. *When will the collector collect all the accumulated bottles?*
11. *Who will collect the bottles left in the system?*
12. *After the system gathers them, where will the bottles end up?*
13. *Who will take accumulated bottles in the system*
14. *What benefits will this system provide for the students and the school?*

SCS Form No.2

Republic of the Philippines
City of Tagaytay
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SCHOOL OF COMPUTER STUDIES

July 4, 2024

JEFERLYN A. AÑONUEVO, MIT
Dean, School of Computer Studies
This College

Madam,

We wish to apply for an oral review of the **title proposal** of our thesis entitled **Development of Arduino-Based System for Converting Plastic Bottles into Points to Duty Hours in City College of Tagaytay** on July 08, 2024 at 9:00am at the City College of Tagaytay.

Thank you.

Respectfully yours,

Baral, Renzo Symon

Cadacio, Daniel Jr.

Caretas, Clark Jude

Castillo, Michaela

Florentino, Erika Roseann

Recommending Approval:

ANGELITO M. CARAAN
Adviser

FLORENCE R. MANALO
Unit Research Coordinator

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
SCHOOL OF COMPUTER STUDIES

Department of Information Technology

REQUEST FOR APPROVAL OF CAPSTONE PROJECT TITLE

Student Proponents: **Baral, Renzo Symon T.**
Cadacio, Daniel T. Jr.
Caretas, Clark Jude S.
Castillo, Michaela R.
Florentino, Erika Roseann S.

Proposed Title: **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay**

Research Instructor **ANGELITO M. CARAAN**

Recommending Approval

FLORENCE R. MANALO
Unit Research Coordinator

NOEL JR. G. GARCIA
Chair

Approved

JEFERLYN A. AÑONUEVO, MIT
School Dean

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
SCHOOL OF COMPUTER STUDIES

Department of Information Technology

RESULT OF TITLE PROPOSAL DEFENSE

This capstone project entitled **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay,** prepared and submitted by **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.,** in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Technology, is recommended for **APPROVAL.**

ANGELITO M. CARAAN
Adviser

Approved by the PANEL OF EXAMINERS for ORAL DEFENSE with a grade of PASSED with **MINOR REVISION**

PANEL OF EVALUATORS

FLORENCE R. MANALO
Member

AILA MARIE E. VELASCO
Member

ALDWIN KARLO M. ANGCAYA
Chair

Accepted as partial fulfillment of the requirements for the degree Bachelor of Science in Information Technology

FLORENCE R. MANALO
Unit Research Coordinator

JEFERLYN A. AÑONUEVO, MIT
School Dean

SCS Form No.1

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
Akle St., Kaybagal South, Tagaytay City 4120
Tel. Nos. (046) 483-0470 / (046) 483 -0672

SCHOOL OF COMPUTER STUDIES

ROUTING SLIP FOR CAPSTONE PROJECT

Names: **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.**

Title of Study: **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay**

Please Check: [√] Outline [ ] Final Manuscript

Designation: Name of Faculty Concerned		Date Received	Date Released	Remarks
Adviser: **ALDWIN KARLO M. ANGCAYA**				
	1	8-12-2024	08 12 2024	
	2			
	3			
Unit Research Coordinator: **ANGELITO M. CARAAN**				
	1	8/12/2024	8/12/2024	per revision
	2			
	3			
Program Coordinator: **JAY-R T. ROLLO**				
	1	8/12/2024	8/12/2024	
	2			
	3			
IT Department Head: **NOEL JR. G. GARCIA**				
	1	8/12/24	8/12/24	
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English Critic:				
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	3			
Dean: **JEFERLYN A. AÑONUEVO**				
	1	8/13/2024	8/13/2024	
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	3			

SCS Form No.2

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
Akle St., Kaybagal South, Tagaytay City 4120
Tel. Nos. (046) 483-0470 / (046) 483 -0672

SCHOOL OF COMPUTER STUDIES

August 8, 2024

JEFFERLYN A. AÑONUEVO
Dean, School
This College

Madam,

We wish to apply for an oral review of the outline/final result of our thesis entitled **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay** on 9/13/24 at 9:00am at the City College of Tagaytay

Thank you.

Respectfully yours,

Baral, Renzo Symon T.

Cadacio, Daniel T. Jr..

Caretas, Clark Jude S.

Castillo, Michaela R.

Florentino, Erika Roseann S.

Recommending Approval:

ALDWIN KARLO M. ANGCAYA
Adviser

8-12-24
Date

ANGELITO M. CARAAN
Unit Research Coordinator

8/12/24
Date

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
SCHOOL OF COMPUTER STUDIES

Department of Information Technology

APPROVAL SHEET
Capstone Project

This capstone project entitled **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay,** prepared and submitted by **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.,** in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Technology, is recommended for **OUTLINE DEFENSE.**

Date of Outline Defense: September 13, 2024

ALDWIN KARLO M. ANGCAYA
Adviser

JONEL M. GATDULA
Technical Critic

PANEL OF EVALUATORS

NOEL JR. G. GARCIA
Member

JAY R T. ROLLO
Member

ANGELITO M. CARAAN
Chair

Recommending Approval:

FLORENCE R. MANALO
Unit Research Coordinator

Approved:

JEFERLYN A. AÑONUEVO, MIT
School Dean

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
SCHOOL OF COMPUTER STUDIES

Department of Information Technology

RESULT OF OUTLINE DEFENSE

This capstone project entitled **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay,** prepared and submitted by **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.,** in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Technology, is recommended for **APPROVAL.**

ALDWIN KARLO M. ANGCAYA
Adviser

JONEL M. GATDULA
Technical Critic

Approved by the PANEL OF EXAMINERS for ORAL DEFENSE with a grade of PASSED with **MINOR REVISION**

PANEL OF EVALUATORS

NOEL JR. G. GARCIA
Member

JAY R T. ROLLO
Member

ANGELITO M. CARAAN
Chair

Accepted as partial fulfillment of the requirements for the degree Bachelor of Science in Information Technology

FLORENCE R. MANALO
Unit Research Coordinator

JEFERLYN A. AÑONUEVO, MIT
School Dean

Form 2 (Request for Thesis Adviser and Technical Critic)

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
SCHOOL OF COMPUTER STUDIES

Department of Computer Science

REQUEST FOR THESIS ADVISER AND TECHNICAL CRITIC

Student Proponents: **Baral, Renzo Symon T.**
Cadacio, Daniel T. Jr
Caretas, Clark Jude S.
Castillo, Michaela R.
Florentino, Erika Roseann S.

Thesis Title:
ARDUINO-BASED PLASTIC BOTTLE CONVERSION INTO POINTS TO DUTY HOURS IN CITY COLLEGE OF TAGAYTAY

CONFORME

CHRISTIAN ANDA — Adviser — 12-5-24 Date

JONEL GATDULA — Technical Critic — 12-5-24 Date

NOTED

NOEL JR. GARCIA — Research Coordinator — 12-5-24 Date

APPROVED

JEFERLYN A. ANONUEVO, MIT — School Dean — 12/5/24 Date

SCS Form No.1

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
Akle St., Kaybagal South, Tagaytay City 4120
Tel. Nos. (046) 483-0470 / (046) 483 -0672

SCHOOL OF COMPUTER STUDIES

ROUTING SLIP FOR CAPSTONE PROJECT

Names: **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.**

Title of Study: **ARDUINO-BASED PLASTIC BOTTLE CONVERSION INTO POINTS TO DUTY HOURS IN CITY COLLEGE OF TAGAYTAY**

Please Check: ☐ Outline ☑ Final

Designation: Name of Faculty Concerned		Date		Remarks
		Received	Released	
Adviser: **CHRISTIAN R. ANDA**				
	1	3/13/25	3/13/25	
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	3			
Unit Research Coordinator: **NOEL JR. G. GARCIA**				
	1	3/13/25	3/13/25	
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	3			
Program Coordinator: **JAY-R T. ROLLO**				
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	3			
IT Department Head: **NOEL JR. G. GARCIA**				
	1	3/13/25	3/13/25	
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English Critic:				
	1			
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Dean: **JEFERLYN A. AÑONUEVO**				
	1	3/13/25	3/13/25	
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SCS Form No.2

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
Akle St., Kaybagal South, Tagaytay City 4120
Tel. Nos. (046) 483-0470 / (046) 483 -0672

SCHOOL OF COMPUTER STUDIES

March 13, 2025

JEFFERLYN A. AÑONUEVO
Dean, School
This College

Madam,

We wish to apply for an oral review of the final result of our thesis entitled **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay** on 3/19/25 at 8:00am at the City College of Tagaytay

Thank you.

Respectfully yours,

Baral, Renzo Symon T.

Cadacio, Daniel T. Jr.

Caretas, Clark Jude S.

Castillo, Michaela R.

Florentino, Erika Roseann S.

Recommending Approval

Christian R. Anda
Adviser
3/13/25
Date

Noel Jr. G. Garcia
Unit Research Coordinator
3/13/25
Date

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
SCHOOL OF COMPUTER STUDIES

Department of Information Technology

APPROVAL SHEET
Capstone Project

This capstone project entitled **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay,** prepared and submitted by **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.,** in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Technology, is recommended for **FINAL DEFENSE.**

Date of Final Defense: Mach 19, 2025

CHRISTIAN R. ANDA
Adviser

JONEL M. GATDULA
Technical Critic

PANEL OF EVALUATORS

JUEL COPER
Member

NOEL JR. G. GARCIA
Member

JEFERLYN A. AÑONUEVO, MIT
Chair

Recommending Approval:

NOEL JR. G. GARCIA
Unit Research Coordinator

Approved:

JEFERLYN A. AÑONUEVO, MIT
School Dean

Republic of the Philippines
City of Tagaytay
CITY COLLEGE OF TAGAYTAY
SCHOOL OF COMPUTER STUDIES
Department of Information Technology

APPROVAL SHEET

Final Capstone Project Manuscript

This capstone project entitled **Arduino-Based Plastic Bottle Conversion into Points to Duty Hours in City College of Tagaytay,** prepared and submitted by **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.,** in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Technology, is recommended for **APPROVAL.**

CHRISTIAN R. ANDA
Adviser

JONEL M. GATDULA
Technical Critic

Approved by the PANEL OF EXAMINERS for FINAL DEFENSE with a grade of PASSED with **MINOR REVISION**

PANEL OF EVALUATORS

JUEL COPER
Member

NOEL JR. G. GARCIA
Member

JEFERLYN A. AÑONUEVO, MIT
Chair

Accepted as partial fulfillment of the requirements for the degree Bachelor of Science in Information Technology

NOEL JR. G. GARCIA
Unit Research Coordinator

JEFERLYN A. AÑONUEVO, MIT
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SCS Form No.1

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SCHOOL OF COMPUTER STUDIES

ROUTING SLIP FOR CAPSTONE PROJECT

Names: **Baral, Renzo Symon T., Cadacio, Daniel T. Jr., Caretas, Clark Jude S., Castillo, Michaela R., Florentino, Erika Roseann S.**

Title of Study: **ARDUINO-BASED PLASTIC BOTTLE CONVERSION INTO POINTS TO DUTY HOURS IN CITY COLLEGE OF TAGAYTAY**

Please Check: ☐ Outline ☑ Final Manuscript

Designation: Name of Faculty Concerned		Date Received	Date Released	Remarks
Adviser: **CHRISTIAN R. ANDA**				
	1			
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	3			
Unit Research Coordinator: **NOEL JR. G. GARCIA**				
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Program Coordinator: **JAY-R T. ROLLO**				
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IT Department Head: **NOEL JR. G. GARCIA**				
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ENGLISH CRITIC: **JEFF JEREMIAH C. PEREA**				
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Dean: **JEFERLYN A. AÑONUEVO**				
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Appendix D. Test Results

UNIT TESTING

Materials/Peripherals	Findings	Solution	Status	Date
HC-SR04 Ultrasonic Sensor	None	None	Working	11-14-24
Servo Motor	None	None	Working	11-14-24
Loadcell Amplifier	None	None	Working	11-15-24
Weight Sensor 3kg (kilograms)	None	None	Working	11-16-24
Laser Beam	None	None	Working	11-18-24
PWM Servo Driver-PCA9685	None	None	Working	11-18-24
DC-DC Buck Converter LM2596S	None	None	Working	11-18-24
Power Module	None	None	Working	11-18-24
Thermal Printer	None	None	Working	01-14-25
I2C LCD Panel	None	None	Working	02-07-25
Matrix Membrane Keypad	Hard touch	Adjust the delay	Working	02-07-25
RTC Module	None	None	Working	02-15-25
LED Light (red)	None	None	Working	02-15-25
Buzzer	None	None	Working	02-18-25
Mini UPS	None	None	Working	03-13-25

INTEGRATION TESTING

	Findings	Status	Date
Arduino Mega 2560	Controls the functions of components for converting, counting, accepting, and rejecting of plastic bottles	Working	10-10-24

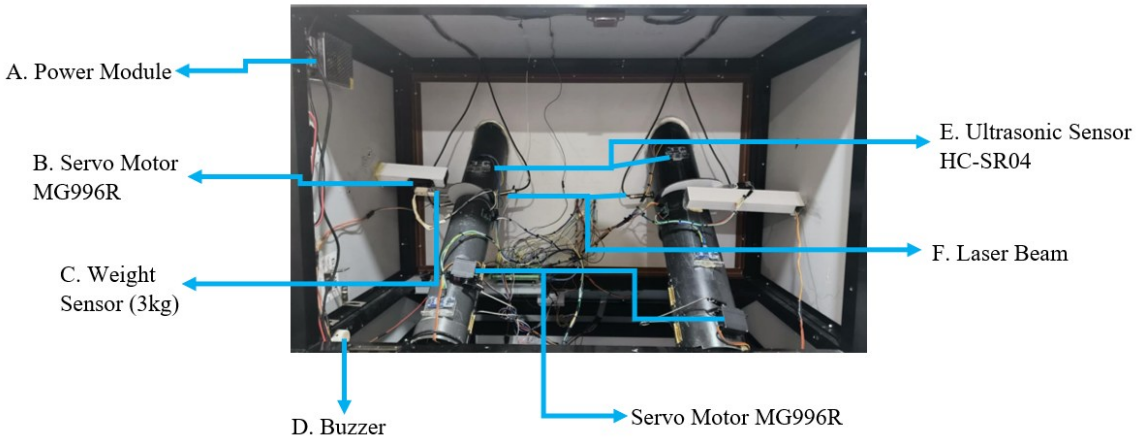
SYSTEM TESTING

	Findings	Status	Date
Student ID Module	Allowing the student to enter their student number	Working	02-07-25
Recognition Module	Can recognize the deposited object whether it is plastic bottle or not.	Working	02-20-25
Counting Module	Can count the deposited plastic bottles	Working	02-20-25
Print Module	Can print the transaction process from the prototype	Working	02-22-25

PERFORMANCE TESTING

	Findings	Status	Date
Student ID Module	The prototype can easily record the entered student number	Working	03-07-25
Recognition Module	The sensors for recognizing the deposited objects are responsive and accurate	Working	03-07-25
Counting Module	Display the counting of plastic bottles is accurate	Working	03-07-25
Print Module	The prototype consistently prints the records of each transaction	Working	03-13-25

Appendix E. Operation Manual/User Guide



Appendix Figure 1. Prototype Components Overview

A. **Power Module:** This is used to supply electricity only to the Laser Beam. It is isolated from other components.

B. **Servo Motor MG996R:** These act as an acceptor and rejector of the plastic bottles to be deposited.

C. **Weight Sensor (3kg):** This is used to measure the weight of plastic bottles and other deposited trash or object.

D. **Buzzer:** This served as an indicator to show if the bin is full. It makes a buzzing sound when the bin is full.

E. **Ultrasonic Sensor HC-SR04:** These act as the sensors that recognize the plastic bottles or other deposited object.

F. **Laser Beam:** These detect plastic bottles by sending a light beam to a receiver. If the light is blocked, the prototype won't accept the deposited object.

Appendix Figure 2. User Interface of the Prototype

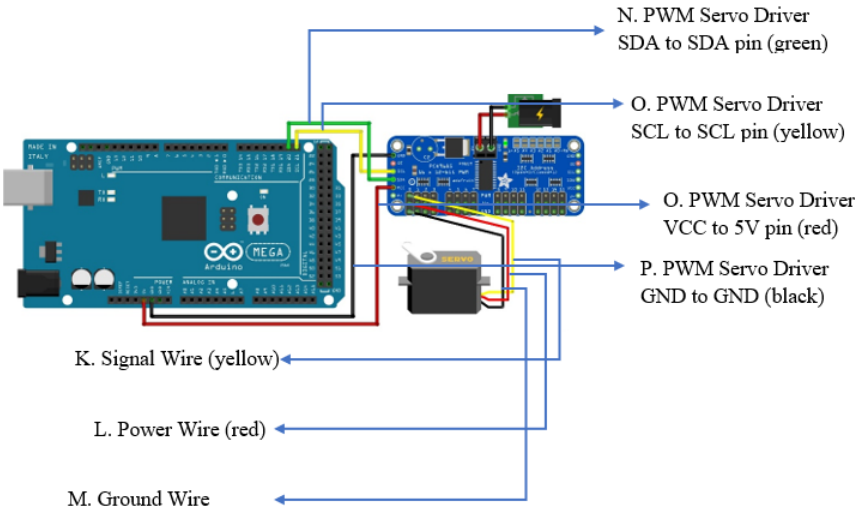
G. I2C LCD Panel: It is used to display the transaction of each students. It helps the students to monitor each transaction.

H. Matrix Membrane Keypad: This served as the main input tool for the prototype, allowing students to press buttons to input their student number.

I. LED (red): This served as the indicator signaling that the bin is full. It will light up when the bin is full.

J. Thermal Printer: It is used to print the record of transaction history, allowing the students to check if the transaction they made is correct.

Set Up



Appendix Figure 3. Wiring Connections for PWM Servo Driver

K. Signal Wire (yellow): Connect the yellow wire from servo motor to PWM Servo Driver.

L. Power Wire (red): Connect the red wire from servo motor to PWM Servo Driver.

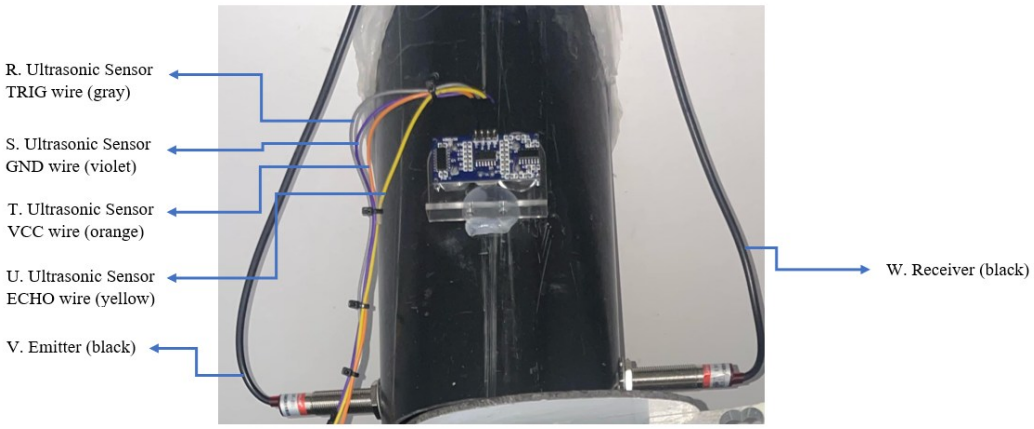
M. Ground Wire (black): Connect the black wire from servo motor to PWM Servo Driver.

N. PWM Servo Driver SDA to SDA pin (green): Connect the green wire of SDA from PWM Servo Driver to SDA of Arduino board.

O. PWM Servo Driver SCL to SCL pin (yellow): Connect the yellow wire of SCL from PWM Servo Driver to SCL of Arduino board.

P. PWM Servo Driver VCC to 5V pin (red): Connect the red wire of VCC from PWM Servo Driver to 5V of Arduino board.

Q. PWM Servo Driver GND to GND (black): Connect the black wire of GND from PWM Servo Driver to GND of Arduino board.



Appendix Figure 4. Wiring Connections for Ultrasonic Sensor and Laser Beam

R. Ultrasonic Sensor TRIG wire (gray): Connect the gray wire of TRIG pin from Ultrasonic Sensor to Arduino board digital pins.

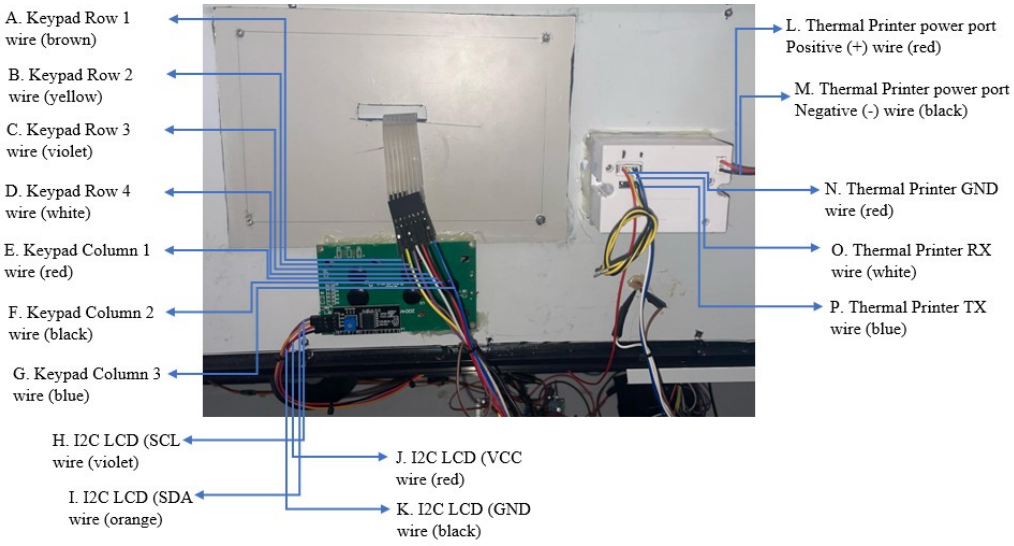
S. Ultrasonic Sensor GND wire (violet): Connect the violet wire of GND pin from Ultrasonic Sensor to Arduino board GND or negative (-) pin.

T. Ultrasonic Sensor VCC wire (orange): Connect the orange wire of VCC pin from Ultrasonic Sensor to Arduino board 5v or positive (+) pin.

U. Ultrasonic Sensor ECHO wire (yellow): Connect the yellow wire of ECHO pin from Ultrasonic Sensor to Arduino board digital pins.

V. Laser Beam Emitter (black): Connect the VCC wire from Laser Beam to 5v output of the power module, GND from laser beam to GND of the power module, and IR OUT to digital pin of Arduino board.

W. Laser Beam Receiver (black): Connect the VCC wire from Laser Beam to 5v output of the power module, GND from laser beam to GND of the power module, and IR OUT to digital pin of Arduino board.



Appendix Figure 4. Wiring Connections for I2C LCD, Keypad, and Thermal Printer

A. **Keypad Row 1 wire (brown):** Connect the brown wire of Row 1 from keypad to Arduino digital pins.

B. **Keypad Row 2 wire (yellow):** Connect the yellow wire of Row 2 from keypad to Arduino digital pins.

C. **Keypad Row 3 wire (violet):** Connect the violet wire of Row 3 from keypad to Arduino digital pins.

D. **Keypad Row 4 wire (white):** Connect the white wire of Row 4 from keypad to Arduino digital pins.

E. **Keypad Column 1 wire (red):** Connect the red wire of Column 1 from keypad to Arduino digital pins.

F. **Keypad Column 2 wire (black):** Connect the black wire of Column 2 from keypad to Arduino digital pins.

G. **Keypad Column 3 wire (blue):** Connect the blue wire of Column 3 from keypad to Arduino digital pins.

H. **I2C LCD (SCL wire (violet):** Connect the violet wire of SCL from LCD to Arduino digital pins.

I. **I2C LCD (SDA wire (orange):** Connect the orange wire of SDA from LCD to Arduino digital pins.

J. **I2C LCD (VCC wire (red):** Connect the orange wire of VCC from LCD to Arduino 5v or positive (+) pin.

K. **I2C LCD (GND wire (black):** Connect the orange wire of GND from LCD to Arduino GND or negative (-) pin.

L. **Thermal Printer power port Positive (+) wire (red):** Connect the red wire of positive from Thermal Printer power port to 5V DC Adapter.

M. **Thermal Printer power port Negative (-) wire (black):** Connect the red wire of negative from Thermal Printer power port to 5V DC Adapter.

N. **Thermal Printer GND wire (red):** Connect the red wire of GND from Thermal Printer to Arduino GND or negative pin.

O. **Thermal Printer RX wire (white):** Connect the white wire of RX from Thermal Printer to Arduino TX pin.

P. **Thermal Printer TX wire (blue):** Connect the white wire of TX from Thermal Printer to Arduino RX pin.

Start Up

Appendix Figure 5. Powering the Prototype

NOTE: Before connecting the thermal printer, ensure that the UPS is POWERED ON to avoid auto printing.

1. Connect the thermal printer and power supply to the extension.
2. Plug the extension into the power outlet.
3. Plug in the USB Cable of Arduino Mega Power 2560 on the 5v Port of the UPS.

Maintenance

1. Install the prototype in a ventilated area to prevent electronics from overheating during class hours in the OSES room.
2. Keep the prototype dry to avoid malfunctions or short circuits.
3. Regularly check the plug connection to prevent short circuits and ensure the thermal printer has enough ticket paper.
4. Only authorized personnel should handle wiring and repairs to ensure proper maintenance.
5. Secure all loose parts or components inside the prototype to prevent damage from vibration or movement.
6. Test the sensors and bottle counting transaction to ensure correct detection and recording.
7. Keep the sensors clean to avoid error in recognizing the plastic bottles.

Appendix F. Program Sample

```
#include <Wire.h>
#include <Adafruit_PWMServoDriver.h>
#include <LiquidCrystal_I2C.h>  // Include the LiquidCrystal_I2C library
#include <HX711.h>  // Include the HX711 library for the load cell
#include <Keypad.h>  // Include the Keypad library
#include "Adafruit_Thermal.h"  // Include the Adafruit Thermal Printer library
#include <RTClib.h>  // Include the RTC library

// Pin Definitions
const int trigPin1 = 9;
const int echoPin1 = 10;
const int trigPin2 = 11;  // Second ultrasonic sensor trig pin
const int echoPin2 = 12;  // Second ultrasonic sensor echo pin
const int trigPin3 = 4;   // Third ultrasonic sensor trig pin
const int echoPin3 = 5;   // Third ultrasonic sensor echo pin
const int trigPin4 = 6;   // Fourth ultrasonic sensor trig pin
const int echoPin4 = 7;   // Fourth ultrasonic sensor echo pin
const int trigPin5 = 31;  // Fifth ultrasonic sensor trig pin
const int echoPin5 = 32;  // Fifth ultrasonic sensor echo pin
const int proximitySensorPin1 = 29; // First proximity sensor pin
const int proximitySensorPin2 = 30; // Second proximity sensor pin
const int buzzerPin = 33; // Buzzer pin
const int ledPin = 34;    // LED pin

// Load Cell Pins
const int LOADCELL1_DOUT_PIN = 2;  // HX711 data pin for load cell 1 (DT)
const int LOADCELL1_SCK_PIN = 3;   // HX711 clock pin for load cell 1 (SCK)
const int LOADCELL2_DOUT_PIN = 8;  // HX711 data pin for load cell 2 (DT)
const int LOADCELL2_SCK_PIN = 13;  // HX711 clock pin for load cell 2 (SCK)

// Keypad Setup
const byte ROWS = 4;  // 4 rows
const byte COLS = 3;  // 3 columns
char keys[ROWS][COLS] = {
  {'1', '2', '3'},  // Row 1
  {'4', '5', '6'},  // Row 2
  {'7', '8', '9'},  // Row 3
  {'*', '0', '#'}   // Row 4
};
byte rowPins[ROWS] = {22, 23, 24, 25};  // Connect to the row pinouts of the keypad
byte colPins[COLS] = {26, 27, 28};      // Connect to the column pinouts of the keypad
Keypad keypad = Keypad(makeKeymap(keys), rowPins, colPins, ROWS, COLS);

// Create PWM servo driver instance
Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();

// Initialize the LCD with I2C address 0x27, 16 columns, and 2 rows
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Initialize the HX711 for the load cells
HX711 loadCell1;
HX711 loadCell2;
```

```
// Thermal Printer Setup
#include "SoftwareSerial.h"
#define TX_PIN 18  // Define the TX pin for the thermal printer
#define RX_PIN 19  // Define the RX pin for the thermal printer
SoftwareSerial printerSerial(RX_PIN, TX_PIN);  // Create a SoftwareSerial object
Adafruit_Thermal printer(&printerSerial);  // Create a thermal printer object

// RTC Setup
RTC_DS3231 rtc;  // Create an RTC object

// Constants
const int servoMin = 150;  // Min pulse length (servo closed)
const int servoMax = 600;  // Max pulse length (servo open)
const int distanceThreshold = 5;  // Threshold distance (cm)
const float MIN_WEIGHT_THRESHOLD_1 = 5.0;  // Minimum weight threshold for load cell 1 in grams
const float MAX_WEIGHT_THRESHOLD_1 = 35.0; // Maximum weight threshold for load cell 1 in
grams
const float MIN_WEIGHT_THRESHOLD_2 = 2.0;  // Minimum weight threshold for load cell 2 in grams
const float MAX_WEIGHT_THRESHOLD_2 = 10.0; // Maximum weight threshold for load cell 2 in
grams

// Variables
int detectionCount = 0;  // Counter for Ultrasonic 2 detections
bool allowDetection = true;  // Flag to allow or block detections
unsigned long lastDetectionTime = 0;  // Timestamp of the last detection
const unsigned long detectionDelay = 3000;  // 3-second delay between detections
float currentWeight = 0.0;  // Variable to store the current weight for load cell 1
float currentWeight2 = 0.0; // Variable to store the current weight for load cell 2

// Student ID Variables
String studentID = "";  // Store the entered Student ID
bool isEnteringID = false;  // Flag to indicate if the user is entering an ID
bool isConfirmingID = false;  // Flag to indicate if the user is confirming the ID
bool isInsertingBottles = false;  // Flag to indicate if the user is inserting bottles
bool isPrintingTicket = false;  // Flag to indicate if the user is printing the ticket
// Points Variables
int pointsUltrasonic2 = 0;  // Points from Ultrasonic 2 (1 point = 3 minutes)
int pointsUltrasonic4 = 0;  // Points from Ultrasonic 4 (1 point = 1 minute)

// Timing Variables
unsigned long lastSensorScanTime = 0;  // Timestamp of the last sensor scan
const unsigned long sensorScanInterval = 2000;  // 2-second interval for sensor scans

// Keypad Timing Variables
unsigned long lastKeypadCheckTime = 0;  // Track the last time the keypad was checked
const unsigned long keypadCheckInterval = 100;  // Check the keypad every 100ms

// Variable to store the time when "Not Accepted" is displayed
unsigned long notAllowedDisplayTime = 0;

// Flag to track if a student ID has been entered
bool studentIDEntered = false;

bool isEnterValidIDScreen = false;

// Flag to track if Ultrasonic 5 is detecting an object
```

```
bool ultrasonic5Detected = false;

// Function to map angle to pulse length
int angleToPulse(int angle) {
  return map(angle, 0, 45, servoMin, servoMax);
}

void setup() {
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin2, OUTPUT);  // Configure second ultrasonic sensor trig pin
  pinMode(echoPin2, INPUT);   // Configure second ultrasonic sensor echo pin
  pinMode(trigPin3, OUTPUT);  // Configure third ultrasonic sensor trig pin
  pinMode(echoPin3, INPUT);   // Configure third ultrasonic sensor echo pin
  pinMode(trigPin4, OUTPUT);  // Configure fourth ultrasonic sensor trig pin
  pinMode(echoPin4, INPUT);   // Configure fourth ultrasonic sensor echo pin
  pinMode(trigPin5, OUTPUT);  // Configure fifth ultrasonic sensor trig pin
  pinMode(echoPin5, INPUT);   // Configure fifth ultrasonic sensor echo pin
  pinMode(proximitySensorPin1, INPUT);  // Configure first proximity sensor pin as input
  pinMode(proximitySensorPin2, INPUT);  // Configure second proximity sensor pin as input
  pinMode(buzzerPin, OUTPUT); // Configure buzzer pin as output
  pinMode(ledPin, OUTPUT);    // Configure LED pin as output

  pwm.begin();
  pwm.setPWMFreq(60);  // Set PWM frequency to 60 Hz

  // Initialize the LCD
  lcd.begin(16, 2);  // Initialize the LCD with 16 columns and 2 rows
  lcd.backlight();  // Turn on the backlight
  lcd.print("      WELCOME      ");  // Display welcome message
  lcd.setCursor(0, 1);
  lcd.print("                ");
  lcd.print("Click # to start");

  // Initialize the load cells
  loadCell1.begin(LOADCELL1_DOUT_PIN, LOADCELL1_SCK_PIN);
  loadCell1.set_scale(2280.f);  // Calibration factor for your load cell (adjust as needed)
  loadCell1.tare();  // Reset the scale to zero

  loadCell2.begin(LOADCELL2_DOUT_PIN, LOADCELL2_SCK_PIN);
  loadCell2.set_scale(2280.f);  // Calibration factor for your load cell (adjust as needed)
  loadCell2.tare();  // Reset the scale to zero

  // Initialize the thermal printer
  printerSerial.begin(9600);  // Start the printer serial communication
  printer.begin();  // Initialize the thermal printer

  // Initialize the RTC
  if (!rtc.begin()) {
    Serial.println("Couldn't find RTC");
    while (1);
  }

  // Set the RTC to the date & time this sketch was compiled (if not already set)
  if (rtc.lostPower()) {
    Serial.println("RTC lost power, setting the time!");
```

```
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));
  }

  Serial.begin(9600);
}

void loop() {
  int proximitySensorState1 = digitalRead(proximitySensorPin1);  // Read the state of the first proximity
sensor
  int proximitySensorState2 = digitalRead(proximitySensorPin2);  // Read the state of the second proximity
sensor
  static bool welcomeScreenActive = true;  // Flag to track if the welcome screen is active
  static bool askToInsertBottles = false; // Flag to track if the system is asking to insert bottles
  static bool isCountingActive = false;   // Flag to track if the counting function is active
  static bool isLEDConfirmationActive = false; // Flag to track if the LED confirmation screen is active

  // Non-blocking keypad logic
  unsigned long currentTime = millis();
  if (currentTime - lastKeypadCheckTime >= keypadCheckInterval) {
    lastKeypadCheckTime = currentTime;  // Update the last keypad check time

    char key = keypad.getKey();
    if (key) {
      if (welcomeScreenActive) {
        if (key == '#') {  // Transition from welcome screen to LED confirmation
          welcomeScreenActive = false;  // Disable the welcome screen
          isLEDConfirmationActive = true;  // Enable LED confirmation screen
          lcd.clear();
          lcd.print("Is the green LED  ");
          lcd.setCursor(0, 1);
          lcd.print("blinking? *:Yes #:No");
        } else {
          // Ignore any other key presses during the welcome screen
          Serial.println("Only '#' is allowed during the welcome screen”.);
        }
      } else if (isLEDConfirmationActive) {
        if (key == '#') {  // User confirms LED is blinking
          isLEDConfirmationActive = false;  // Disable LED confirmation screen
          lcd.clear();
          lcd.print("Enter Student ID:   "); // Prompt for Student ID
          isEnteringID = true;  // Enable Student ID entry
        } else if (key == '*') {  // User denies LED is blinking
          isLEDConfirmationActive = false;  // Disable LED confirmation screen
          welcomeScreenActive = true;  // Return to welcome screen
          lcd.clear();
          lcd.print("      WELCOME      ");
          lcd.setCursor(0, 1);
          lcd.print("                   ");
          lcd.print("Click # to start");
        } else {
          // Ignore any other key presses during the LED confirmation screen
          Serial.println("Only '#' or '*' are allowed during the LED confirmation screen”.);
        }
      } else if (isEnteringID && key == '#') {  // Confirm Student ID
        if (studentID.length() == 10) {  // Only allow confirmation if Student ID is not empty
          isEnteringID = false;
```

```
    studentIDEntered = true;  // Set the flag to indicate that a student ID has been entered
    lcd.clear();
    lcd.print("Student ID:");
    lcd.setCursor(0, 1);
    lcd.print(studentID);  // Display the entered Student ID
    Serial.print("Student ID Entered: ");
    Serial.println(studentID);

    // Ask if the user wants to insert bottles
    askToInsertBottles = true;
    lcd.clear();
    lcd.print("Is ID Correct?");
    lcd.setCursor(0, 1);
    lcd.print("*: No #: Yes ");
   } else {
    lcd.clear();
    lcd.print("INVALID ID      ");
    lcd.setCursor(0, 1);
    lcd.print("Click * to Retry");
    isEnterValidIDScreen = true;// Prompt for Student ID again
    Serial.println("Student ID is empty. Please enter a valid ID”.);
   }

} else if (isEnterValidIDScreen) {  // Only allow '*' to be pressed in the "Enter Valid ID" screen
   if (key == '*') {  // User presses '*' to re-enter the ID
    isEnterValidIDScreen = false;  // Exit the "Enter Valid ID" screen
    lcd.clear();
    lcd.print("Enter Student ID:   ");  // Prompt for Student ID again
    studentID = "";  // Reset the Student ID
    isEnteringID = true;  // Enable Student ID entry
   } else {
    // Ignore any other key presses during the "Enter Valid ID" screen
    Serial.println("Only '*' is allowed during the 'Enter Valid ID' screen”.);
   }
} else if (askToInsertBottles) {  // Only allow '#' or '*' to be pressed
   if (key == '#') {  // User confirms to insert bottles
    askToInsertBottles = false;
    isCountingActive = true;  // Proceed to counting function
    lcd.clear();
    lcd.print(" PLEASE INSERT YOUR  ");
    lcd.print("PLASTIC BOTTLES..”.);
   } else if (key == '*') {  // User declines to insert bottles
    askToInsertBottles = false;
    welcomeScreenActive = true;  // Return to welcome screen
    lcd.clear();
    lcd.print("      WELCOME      ");
    lcd.setCursor(0, 1);
    lcd.print("                ");
    lcd.print("Click # to start");
    studentID = "";  // Reset the Student ID
    studentIDEntered = false;  // Reset the flag
   } else {
    // Ignore any other key presses during the "IS THE ID CORRECT?" screen
    Serial.println("Only '#' or '*' are allowed during the ID confirmation screen”.);
   }
} else if (isCountingActive && key == '#') {  // Print ticket during counting
```

```
  if (pointsUltrasonic2 > 0 || pointsUltrasonic4 > 0) {  // Check if points are greater than 0
    isCountingActive = false;  // Stop counting
    welcomeScreenActive = true;  // Return to welcome screen

    // Display "PLEASE WAIT..". message on the LCD
    lcd.clear();
    lcd.print("PLEASE WAIT...       ");
    lcd.print("PRINTING”.);

    // Print the ticket
    printReceipt(studentID, pointsUltrasonic2, pointsUltrasonic4);

    // Reset points and Student ID
    pointsUltrasonic2 = 0;
    pointsUltrasonic4 = 0;
    studentID = "";
    studentIDEntered = false;  // Reset the flag

    // Display welcome message
    lcd.clear();
    lcd.print("      WELCOME      ");
    lcd.setCursor(0, 1);
    lcd.print("                   ");
    lcd.print("Click # to start");
  } else {
    lcd.clear();
    lcd.print("No points to print”.);
    delay(2000);  // Display message for 2 seconds
    lcd.clear();
    lcd.print(" PLEASE INSERT YOUR  ");
    lcd.print("PLASTIC BOTTLES..”.);
  }
} else if (key == '*') {  // Clear Student ID
  studentID = "";
  studentIDEntered = false;  // Reset the flag
  lcd.clear();
  lcd.print("Enter Student ID:   ");
  Serial.println("Student ID Cleared”.);
} else if (isEnteringID) {  // Append to Student ID
  studentID += key;
  lcd.setCursor(studentID.length() - 1, 1);  // Move cursor to the next position
  lcd.print(key);  // Display the pressed key
  Serial.print("Key pressed: ");
  Serial.println(key);
} else if (isCountingActive) {  // Only allow '#' and '*' during counting
  if (key == '#' || key == '*') {
    // Handle '#' or '*' key press during counting
    if (key == '#') {  // Print ticket
      if (pointsUltrasonic2 > 0 || pointsUltrasonic4 > 0) {  // Check if points are greater than 0
        isCountingActive = false;  // Stop counting
        welcomeScreenActive = true;  // Return to welcome screen

        // Display "PLEASE WAIT..". message on the LCD
        lcd.clear();
        lcd.print("PLEASE WAIT...       ");
        lcd.print("PRINTING”.);
```

```
          // Print the ticket
          printReceipt(studentID, pointsUltrasonic2, pointsUltrasonic4);

          // Reset points and Student ID
          pointsUltrasonic2 = 0;
          pointsUltrasonic4 = 0;
          studentID = "";
          studentIDEntered = false;  // Reset the flag

          // Display welcome message
          lcd.clear();
          lcd.print("      WELCOME      ");
          lcd.setCursor(0, 1);
          lcd.print("                   ");
          lcd.print("Click # to start");
         } else {
          lcd.clear();
          lcd.print("No points to print".);
          delay(2000);  // Display message for 2 seconds
          lcd.clear();
          lcd.print(" PLEASE INSERT YOUR  ");
          lcd.print("PLASTIC BOTTLES..".);
         }
        } else if (key == '*') {  // Clear Student ID
         studentID = "";
         studentIDEntered = false;  // Reset the flag
         lcd.clear();
         lcd.print("Enter Student ID:   ");
         Serial.println("Student ID Cleared".);
        }
       } else {
        // Ignore any other key presses during counting
        Serial.println("Only '#' or '*' are allowed during counting".);
       }
      } else {  // Start entering Student ID
       isEnteringID = true;
       lcd.clear();
       lcd.print("Enter Student ID:   ");
       lcd.print("                   ");
       lcd.print("Max: 10 char");
       studentID += key;
       lcd.setCursor(0, 1);
       lcd.print(key);  // Display the first key
       Serial.print("Key pressed: ");
       Serial.println(key);
      }
     }
    }

    // Non-blocking sensor scan (counting function)
    if (isCountingActive && currentTime - lastSensorScanTime >= sensorScanInterval) {
     lastSensorScanTime = currentTime;  // Update the last scan time

     // Measure distance for fifth ultrasonic sensor
     long duration5 = getUltrasonicDistance(trigPin5, echoPin5);
```

```
  int distance5 = duration5 * 0.034 / 2;

  // Check if Ultrasonic 5 detects an object
  if (distance5 <= 10 && distance5 > 0) {
    ultrasonic5Detected = true;  // Set the flag to true
    digitalWrite(buzzerPin, HIGH);  // Turn on the buzzer
    digitalWrite(ledPin, HIGH);     // Turn on the LED
    lcd.clear();                    // Clear the LCD
    lcd.print("DON'T DEPOSIT BOTTLE");
    lcd.print("BIN IS FULL");   // Display "The bin is full" message
    delay(2000);                // Keep buzzer, LED, and message on for 2 seconds
    digitalWrite(buzzerPin, LOW);   // Turn off the buzzer
    digitalWrite(ledPin, LOW);      // Turn off the LED
    delay(3000);                // Wait for 3 seconds before next cycle (total 5 seconds)
  } else {
    ultrasonic5Detected = false;  // Set the flag to false
  }

  // Measure distance for first ultrasonic sensor (only if Ultrasonic 5 is not detecting an object)
  if (!ultrasonic5Detected) {
    long duration1 = getUltrasonicDistance(trigPin1, echoPin1);
    int distance1 = duration1 * 0.034 / 2;

    Serial.print("Distance 1: ");
    Serial.println(distance1);

    // Measure distance for third ultrasonic sensor (only if Ultrasonic 5 is not detecting an object)
    long duration3 = getUltrasonicDistance(trigPin3, echoPin3);
    int distance3 = duration3 * 0.034 / 2;

    Serial.print("Distance 3: ");
    Serial.println(distance3);

    // Logic for servo 0 movement (Ultrasonic 1)
    if (studentIDEntered) {  // Only execute if a student ID has been entered
      if (proximitySensorState1 == LOW || proximitySensorState2 == LOW) {  // Either proximity sensor
detects an object
        pwm.setPWM(0, 0, angleToPulse(0));  // Keep servo 0 closed
        Serial.println("Proximity sensor active. Servo 0 remains closed”.);
        lcd.clear();
        lcd.print("Not Allowed        Metal, Glass)       (Covered Bottle”,);
        delay(1000);  // Display "Not Allowed" on the LCD
        notAllowedDisplayTime = millis();  // Record the time when "Not Allowed" is displayed
      } else if (distance1 <= distanceThreshold && distance1 > 0) {
        if (currentWeight < MIN_WEIGHT_THRESHOLD_1 || currentWeight >
MAX_WEIGHT_THRESHOLD_1) {  // Weight out of range
          pwm.setPWM(0, 0, angleToPulse(0));  // Keep servo 0 closed
          Serial.println("Weight out of range. Servo 0 remains closed”.);
          lcd.clear();
          lcd.print("");// Display "Not Allowed" on the LCD
          notAllowedDisplayTime = millis();  // Record the time when "Not Allowed" is displayed
        } else {  // Weight is within range
          Serial.println("Ultrasonic 1 detected within range. Waiting 2 seconds before opening servo 0”.);
          // Wait for 5 seconds
          pwm.setPWM(0, 0, angleToPulse(30));  // Open servo 0 to 45 degrees
          Serial.println("Servo 0 opened to 45 degrees”.);
```

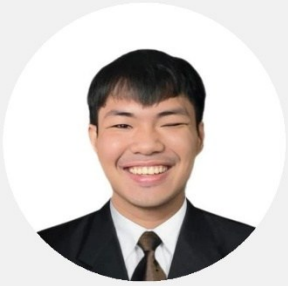
```
          lcd.clear();
          lcd.print("Accepted");
         }
        } else {
         pwm.setPWM(0, 0, angleToPulse(0));  // Return servo 0 to closed position
         Serial.println("No detection or weight out of range. Servo 0 remains closed”.);
        }
       }

      // Logic for servo 2 movement (controlled by ultrasonic 3 and proximity sensor)
      if (studentIDEntered) {  // Only execute if a student ID has been entered
       if (distance3 <= distanceThreshold && distance3 > 0 && proximitySensorState1 == HIGH &&
proximitySensorState2 == HIGH) {
        if (currentWeight2 >= MIN_WEIGHT_THRESHOLD_2 && currentWeight2 <=
MAX_WEIGHT_THRESHOLD_2) {
         // Ultrasonic 3 detects within threshold and both proximity sensors do not detect an object
         Serial.println("Ultrasonic 3 detected within range. Opening servo 2”.);
         pwm.setPWM(2, 0, angleToPulse(30));  // Open servo 2 to 45 degrees
         Serial.println("Servo 2 opened to 45 degrees”.);
         lcd.clear();
         lcd.print("Accepted");
        } else {  // Weight out of range
         pwm.setPWM(2, 0, angleToPulse(0));  // Keep servo 2 closed
         Serial.println("Weight out of range. Servo 2 remains closed”.);
         lcd.clear();
         lcd.print(""); // Display "Not Allowed" on the LCD
         notAllowedDisplayTime = millis();  // Record the time when "Not Allowed" is displayed
        }
       } else {
        pwm.setPWM(2, 0, angleToPulse(0));  // Return servo 2 to closed position
        Serial.println("No detection or proximity sensor active. Servo 2 remains closed”.);
       }
      }
     }

     // Measure distance for second ultrasonic sensor
     long duration2 = getUltrasonicDistance(trigPin2, echoPin2);
     int distance2 = duration2 * 0.034 / 2;

     Serial.print("Distance 2: ");
     Serial.println(distance2);

     // Measure distance for fourth ultrasonic sensor
     long duration4 = getUltrasonicDistance(trigPin4, echoPin4);
     int distance4 = duration4 * 0.034 / 2;

     Serial.print("Distance 4: ");
     Serial.println(distance4);

     // Read proximity sensor states
     int proximitySensorState1 = digitalRead(proximitySensorPin1);  // First proximity sensor
     int proximitySensorState2 = digitalRead(proximitySensorPin2);  // Second proximity sensor

     // Read the current weight from the load cells
     currentWeight = loadCell1.get_units(5);  // Get the average of 5 readings
     if (currentWeight < 0) {
```

```
  currentWeight = 0.0;  // Ensure weight is not negative
}

Serial.print("Weight 1: ");
Serial.print(currentWeight);
Serial.println(" g");

currentWeight2 = loadCell2.get_units(5);  // Get the average of 5 readings
if (currentWeight2 < 0) {
  currentWeight2 = 0.0;  // Ensure weight is not negative
}

Serial.print("Weight 2: ");
Serial.print(currentWeight2);
Serial.println(" g");

// Logic for servo 1 movement (Ultrasonic 2: 1 point = 3 minutes)
if (distance2 <= distanceThreshold && distance2 > 0 && allowDetection) {
  pointsUltrasonic2 += 1;  // Add 1 point (equivalent to 3 minutes)
  updateLCDWithPointsAndTime();  // Update the LCD with points and converted time
  Serial.println("Ultrasonic 2 detected within range. Added 1 point (3 minutes)”.);
  allowDetection = false;  // Block further detections
  lastDetectionTime = millis();  // Record the time of the last detection

  pwm.setPWM(1, 0, angleToPulse(30));  // Open servo 1 to 45 degrees
  Serial.println("Servo 1 opened to 45 degrees”.);
} else {
  pwm.setPWM(1, 0, angleToPulse(0));  // Return servo 1 to closed position
}

// Logic for servo 3 movement (Ultrasonic 4: 1 point = 1 minute)
if (distance4 <= distanceThreshold && distance4 > 0 && allowDetection) {
  pointsUltrasonic4 += 1;  // Add 1 point (equivalent to 1 minute)
  updateLCDWithPointsAndTime();  // Update the LCD with points and converted time
  Serial.println("Ultrasonic 4 detected within range. Added 1 point (1 minute)”.);
  allowDetection = false;  // Block further detections
  lastDetectionTime = millis();

  pwm.setPWM(3, 0, angleToPulse(50));  // Open servo 3 to 45 degrees
  Serial.println("Servo 3 opened to 45 degrees”.);
} else {
  pwm.setPWM(3, 0, angleToPulse(0));  // Return servo 3 to closed position
  Serial.println("No detection. Servo 3 remains closed”.);
}

// Check if 3 seconds have passed since the last detection
if (!allowDetection && (millis() - lastDetectionTime >= detectionDelay)) {
  allowDetection = true;  // Allow the next detection
  Serial.println("3 seconds passed. Ready for next detection”.);
}

// Check if 2 seconds have passed since "Not Allowed" was displayed
if (notAllowedDisplayTime > 0 && (millis() - notAllowedDisplayTime >= 2000)) {
  lcd.clear();  // Clear the LCD screen
  updateLCDWithPointsAndTime();  // Return to the counting display
  notAllowedDisplayTime = 0;  // Reset the timer
```

```
    }
  }

  delay(10);  // Small delay to reduce CPU usage
}

// Function to get ultrasonic distance
long getUltrasonicDistance(int trigPin, int echoPin) {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Measure the duration of the echo signal
  return pulseIn(echoPin, HIGH);
}

// Function to update the LCD with points and converted time
void updateLCDWithPointsAndTime() {
  lcd.clear();
  lcd.print("Points(Big): ");
  lcd.print(pointsUltrasonic2);  // Display points from Ultrasonic 2
  lcd.setCursor(0, 1);
  lcd.print("Points(Small): ");
  lcd.print(pointsUltrasonic4);  // Display points from Ultrasonic 4

  // Convert points to minutes
  int minutesUltrasonic2 = pointsUltrasonic2 * 3;  // 1 point = 3 minutes for Ultrasonic 2
  int minutesUltrasonic4 = pointsUltrasonic4 * 1;  // 1 point = 1 minute for Ultrasonic 4
  int totalMinutes = minutesUltrasonic2 + minutesUltrasonic4;  // Sum of converted minutes

  lcd.setCursor(0, 2);
  lcd.print("Total Mins:");
  lcd.print(totalMinutes);
  lcd.setCursor(20,3);
  lcd.print("Press # to PRINT"); // Display the total converted minutes
}

// Function to print the receipt on the thermal printer
void printReceipt(String studentID, int pointsUltrasonic2, int pointsUltrasonic4) {
  DateTime now = rtc.now();  // Get the current date and time from the RTC

  printer.println("ARDUINO-BASED PLASTIC BOTTLE");
  printer.println("CONVERSION INTO POINTS TO");
  printer.println("DUTY HOURS IN CITY COLLEGE");
  printer.println("OF TAGAYTAY");
  printer.println("                          ");
  printer.println("Student ID: " + studentID);  // Print Student ID
  printer.println("Points(Big): " + String(pointsUltrasonic2));  // Print Points from Ultrasonic 2
  printer.println("Points(Small): " + String(pointsUltrasonic4));  // Print Points from Ultrasonic 4

  // Convert points to minutes
  int minutesUltrasonic2 = pointsUltrasonic2 * 3;  // 1 point = 3 minutes for Ultrasonic 2
  int minutesUltrasonic4 = pointsUltrasonic4 * 1;  // 1 point = 1 minute for Ultrasonic 4
  int totalMinutes = minutesUltrasonic2 + minutesUltrasonic4;  // Sum of converted minutes
```

```
  printer.println("Converted Time: " + String(totalMinutes) + " mins");  // Print total converted minutes
  printer.println("Date: " + String(now.year()) + "-" + String(now.month()) + "-" + String(now.day()));  //
Print Date
  printer.println("Time: " + String(now.hour()) + ":" + String(now.minute()) + ":" + String(now.second()));
// Print Time
  printer.println("                          ");
  printer.println("                          ");
  printer.println("                          ");
  printer.println("    _________________________  ");
  printer.println("         OSES FACULTY       ");
  printer.println("                          ");
  printer.println("------------------------------");
  printer.println("PLEASE PROCEED TO THE OSES");
  printer.println("TO CONFIRM YOUR DUTY HOURS");  // Print Converted Hours
  printer.println("------------------------------");  // Print a separator line
  printer.feed(2);  // Feed 2 lines
}
```

Appendix G. Curricuxlum Vitae



Renzo Symon Baral

CONTACT

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Cavite, Philippines 4119

PERSONAL INFORMATION

Name: Renzo Symon T. Baral
Address: 160 Brgy. Bucal Amadeo, Cavite
Age: 21 years old
Birth date: April 02, 2003
Birthplace: Balayan, Batangas
Gender: Male
Religion: Catholic
Father's Name: Wilson B. Baral.
Mother's Name: Angelita T. Baral

SKILLS

- **Technical Skills:** Proficient in Microsoft Office Tools (Word, Excel, PowerPoint), With basic knowledge in computer troubleshooting
- **Soft Skills:** Problem-Solving, Oral & Written Communication Skills, Team Collaboration
- **Other Skills:** Painting, Driving, Sports (Basketball & Volleyball)

QUALIFICATION

Responsible and passionate about delivering services with quality. Self-motivated to consistently meet the standard requirement of an organization. A collaborative and dependable team player.

EDUCATION

2021 – present
Bachelor of Science in Information Technology
City College of Tagaytay, Tagaytay City

2019 – 2021
Graduate – Senior High School
Infant Jesus Academy of Silang Inc., Silang Cavite

2015 – 2019
Graduate – Junior High School
Infant Jesus Academy of Silang Inc., Silang Cavite

MEMBERSHIP

EXTRA CURRICULAR ACTIVITY / MEMBERSHIP
2018-2019: Kalasag
Coordinating Committee Chairperson
Infant Jesus Academy of Silang Inc., Silang Cavite

2017 – 2018: Children of Mary
Member
Infant Jesus Academy of Silang Inc., Silang Cavite

2015 – 2017: I-Science Society
Member
Infant Jesus Academy of Silang Inc., Silang Cavite

REFERENCES

Mdme. Emedia T. Dela Peña
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Mr. Benjarde Villanueva
Farmer
Phone: 0977-122-3741

I hereby swear that the information stated above are all true and written within my knowledge and belief.

Renzo Symon T. Baral
Applicant

Daniel T. Cadacio Jr.

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Hugo Perez, Trece Martires, Cavite

+09392164432

Skills

- Basic Computer Troubleshooting
- Proficient in Microsoft
- Positive and friendly -attitude
- Ability to work in a team oriented environment
- Work well in high-pressure environment

About

I'm specializing in hardware with a strong interest in IT solutions. I'm passionate about technology and problem-solving, and I recently earned a certificate in robotics. I'm currently focused on expanding my skills in IT infrastructure, system maintenance, and innovative tech solutions.

Educational History

Bachelor of Science in Information Technology | 2021 - 2025

City College of Tagaytay

Information and Communication Technology | 2019 - 2021

Amadeo National High School

Certificate

Rovorave Philiphine Robotics Education | 2019

- Programmed and maintained robots, demonstrating proficiency in robotics technology, responsible for the efficient functioning and performance of robotic systems.

Seminar Attended

TechFair | 2024

- Topic: Techrevolution: Empowering The Next Generation in Future Emerging Technologies.

TechFair | 2025

- Topic: The New Era Of Technologies

CLARK JUDE S. CARETAS

CONTACT

0938-043-5774
clarkjude016@gmail.com
109 Luksuhin Ilaya Alfonso, Cavite

SKILLS

- Good in Communication
- Negotiation
- Fast Learner
- Adaptability
- Time Management and Organization
- Basic Computer Literacy

LANGUAGE

English
Tagalog/Filipino

REFERENCES

Roger G. Mendoza
Brgy. Captain
Phone: 0991-872-9205

Antonio L. De Guzman
Ex Brgy. Captain
Phone: 0923-354-8084

OBJECTIVE

To gain practical experience and develop my skills in a professional environment while contributing to the success of the organization. I aim to apply my academic knowledge to real-world challenges, enhance my abilities, and grow as a valuable team member.

PERSONAL INFORMATION

Name	Clark Jude S. Caretas
Address	Luksuhin Ilaya, Alfonso, Cavite
Birthdate	April 01, 2002
Age	22
Sex	Male
Mother's Name	Myrna Caretas
Father's Name	Rogelio Caretas
Nationality	Filipino
Religion	Catholic

EDUCATION

City College of Tagaytay
Bachelor of Science in Information Technology — 2021 - PRESENT

Senior High School
Victoroious Christian Montessori College Alfonso — 2018 - 2020

Junior High School
Lucsuhin National High School — 2014 - 2018

MICHAELA R. CASTILLO

SITIO APIAD, BRGY. PULONG BUNGA, SILANG, CAVITE
mikaycastillo61@gmail.com
0975-6230-289

PROFILE

Gender: Female

Birth Date: September 30, 2001

Birth Place: Tagaytay, City

Civil Status: Single

Nationality: Filipino

Religion: Roman Catholic

SKILLS

- Easy to Adapt
- Flexible
- Time Management
- Active Listener
- Can work under pressure
- Team work
- Hard-working

OBJECTIVE

To enhance my skills and knowledge that I have learned, to contribute and help the company while gaining new knowledge and improve my skills for the future.

EDUCATIONAL BACKGROUND

TERTIARY: City College of Tagaytay
Bachelor of Science in Information Technology
2021-PRESENT

SENIOR HIGHSCHOOL: Francisco P. Tolentino Integrated School
Humanities and Social Science
2019-2021

JUNIOR HIGHSCHOOL: Francisco P. Tolentino Integrated School
2015-2019

CHARACTER REFERENCE

MYRNA CARETAS
HEALTH WORKER
0912-6632-383

ERIKA ROSEANN S. FLORENTINO

Student

PROFILE

Information Technology student.
I consider my self a responsible and orderly person.
I am looking foward for my OJT experience.

CONTACT ME

0912-663-3284

erikaflrntno@gmail.com

Purok 2, Sinaliw Malaki, Alfonso, Cavite

SKILLS

- Good in Communication
- Fast Learner
- Time Management
- Flexibility

LANGUAGE

Tagalog/Filipino
English

REFERENCES

Liza Punzalan
Secretary of the Mayor
Phone: 0917-526-6312

PERSONAL INFORMATION

Name	Erika Roseann S. Florentino
Address	Sinaliw Malaki, Alfonso, Cavite
Birthdate	January 01, 2001
Age	23
Sex	Female
Mother's Name	Rebecca S. Florentino
Father's Name	Eduardo A. Florentino
Nationality	Filipino
Religion	Catholic

EDUCATION

CITY COLLEGE OF TAGAYTAY

Bachelor of Information Technology

2021 - Present

SENIOR HIGH SCHOOL

National College of Science & Technology

Tech-Voc Automotive NC-II

2016-2018

JUNIOR HIGH SCHOOL

Alfonso National Highschool

2013-2017

EXPERIENCE

- Sangguniang Kabataan Chairperson (2023-Present)
- Automotive Servicing (2018-2020)
- Catering Services (2016-2019)