Republic of the Philippines
Department of Education
TAYSAN SENIOR HIGH SCHOOL
Science, Technology, Engineering and Mathematics

RE- TAPON: RECYCLING ENGINE - TRASH AUTOMATON PROMOTES OPTIMAL RECYCLING AND NURTURES WASTE MANAGEMENT PRACTICES AMONG SENIOR HIGH SCHOOL STUDENTS

A Project Development Study
Presented to the Faculty of Senior High School
TAYSAN SENIOR HIGH SCHOOL
Mahanadiong, Taysan, Batangas

in partial fulfillment of the requirements in
Research in Daily Life 2

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Grade 12 STEM LOVE

February 2024

APPROVAL SHEET

This research study **RE- TAPON: RECYCLING ENGINE - TRASH AUTOMATON PROMOTES OPTIMAL RECYCLING AND NURTURES WASTE MANAGEMENT SKILLS** prepared and submitted by **Berana, Jon Paul S., Catapia, Mary Joy G., Dela Cruz, Angelo John M., Delizo, Ryan Galle B., Lacida, Michaela Joy N., Magadia, Princess A., Perez, Jan Francine M.** in partial fulfillment of the requirements for the Academic Track – Science Technology Engineering and Mathematics Strand been examined and is recommended for acceptance for the final presentation.

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ACKNOWLEDGEMENT

Praise and gratitude are first and foremost due to God, the Almighty, for His favors that continued throughout our research and led to its successful conclusion.

The researchers would also want to convey their profound gratitude to Mrs. Cryzil Berana, their research adviser, for her important guidance, support, and mentorship over the course of our research endeavor. They also want to thank her for teaching them and for her empathy, patience, and wisdom.

Additionally, the researchers would like to express their gratitude and appreciation to the evaluators who voluntarily contributed their time and full cooperation to the research study's successful conclusion. They want to express their gratitude for the time and information they provided for the researchers to conduct this study.

Last but not least, they would like to thank their dearest parents for their thoughtful financial planning and unwavering support throughout the research study's development. Additionally, they are grateful for their words of support during all the late nights we spent conducting the research.

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P.J.F.M.

DEDICATION

This study is the result of the hard work and willingness of the proponents to pass the course. This study is dedicated to everyone who helped and motivated the researchers, especially the parents who supported them all the way. Their help and encouragement, along with the resources they provided, were really important for finishing this study. We also want to thank the teachers who guided the researchers throughout this project. And we're grateful to the school for giving us the chance to learn and work on this study. Most importantly, we dedicate this research to God, who gave us the strength, knowledge, and determination to complete this study.

B.J.P.S.

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LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Title : RE-TAPON: Recycling Engine - Trash Automaton Promotes Optimal Recycling and Nurtures Waste Management Practices among Senior High School Students

Institution : Taysan Senior High School

Department : STEM

Researchers : Berana, Jon Paul S., Catapia, Mary Joy G., Dela Cruz, Angelo John M., Delizo, Ryan Galle B., Lacida, Michaela Joy N., Magadia, Princess A., Perez, Jan Francine M.

Number of Pages :

Type of Document : Project Development Study

Strand : Science, Technology, Engineering, and Mathematics

Grade Level : 12

Research Adviser : Cryzil B. Cantos, LPT, MEd

The study focused on enhancing waste segregation using electronic technology and solar energy, specifically targeting recyclable materials at Taysan Senior High School. The study employed an experimental research design to evaluate the durability, functionality, and usefulness of the RE-TAPON system. The system integrated sensor technology and solar power, achieving high functionality scores (4.62), and emphasized ease of use. However, durability (4.37) received constructive feedback for improvement, while overall usefulness scores (4.52) highlighted accessibility and educational benefits. The findings from the evaluation and research of the RE-TAPON project show significant insights into the enhanced features and specifications of the device. The study recommends widespread adoption in schools, communities, and households to improve waste management practices, support sustainable development goals, and encourage further research for enhanced functionality and cost-efficiency in future replication of electronic trash bins.

Keywords: recycle, smart trash bin, waste management, solar panel

CHAPTER I

THE PROBLEM

This chapter presents the introduction, objectives of the study, the scope, limitations and delimitations, its significance, and the definition of terms respectively.

Introduction

Waste management is a global issue that affects both developed and developing countries. It is the systematic process of collecting, transporting, processing, recycling, and disposing of various types of waste materials, with the primary goal of minimizing environmental impact and protecting public health. (World Bank, 2018). Moreover, it operates at various levels, from individual households to municipalities and industrial facilities. Furthermore, waste management usually starts with collecting garbage and recyclables. This is when all the trash and things that can be recycled are gathered up and will be taken to places where they can be properly disposed of. In connection to this, recycling and composting are important parts of this process as it keeps waste materials out of landfills, prevents waste burning, saves resources and reduces pollution. On the other hand, proper waste management is essential because it mitigates the harmful consequences of waste on the environment and human health. However, improper waste management can lead to negative effects like environmental pollution, health hazards, and reduction of natural resources, making it crucial to implement effective waste management practices. (Smith, 2022)

According to the 2023 study of the World Bank the issue of waste management has evolved significantly. Globally, 2.01 billion tonnes of municipal solid waste is generated yearly, with at least 33 percent of that is not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilograms.. In addition to this, solid waste management poses an ongoing challenge for the Philippines, as highlighted in the National Solid Waste Management Status Report 2008–2018 prepared by the Environmental Management Bureau of the Department of Environment and Natural Resources. Over the 10-year period examined, the report stated that The Philippines was estimated to generate 18.05 million tons of trash.

Moreover, the Philippines has taken significant steps to improve solid waste management through the enactment of RA 9003, also known as the Ecological Solid Waste Management Act (Miguel, 2019). The Ecological Solid Waste Management Act of 2000 (RA 9003), which aims to promote proper waste segregation, recycling, and disposal (Atienza, 2020). However, the implementation of this law faces challenges, including the scarcity of landfill sites and the use of open and controlled dumps. The government has responded to these challenges through initiatives to promote waste segregation and recycling, but there is still a need for good governance and innovative technologies to achieve sound waste management (Atienza, 2020). Despite the potential for a circular economy, the country has yet to fully embrace this concept due to the lack of attention to waste management from the government (Pintor, 2019).

The 2023 study conducted by the World Bank emerges as a pivotal reference in the current research for several compelling reasons. Firstly, it sheds light on the magnitude of the global waste management crisis, emphasizing that billions of tonnes of waste are generated annually, with a substantial portion not being handled appropriately. This underscores the pressing need for responsible waste disposal methods and underscores the importance of cultivating environmental awareness among students and the broader population. Secondly, the study provides invaluable information and diverse perspectives that researchers can integrate into their own investigation. By presenting real-world examples, the study enhances researchers' understanding of the critical challenges associated with waste management, facilitating a more informed and comprehensive approach to their work.

Furthermore, the practical implications of the World Bank study are profound, underscoring the urgency for reform in waste management practices, especially in low-income countries. This aligns seamlessly with the objectives of the current study, which proposes a waste segregation machine incorporating solar panels as a technological innovation. The proposed machine, as inspired by the World Bank's call for action, has the potential to revolutionize waste management practices. By harnessing solar energy, the researchers aim to address environmental concerns while also contributing to economic sustainability. In essence, the alignment between the World Bank study and the current research underscores the imperative for immediate and transformative measures in waste segregation on a global scale.

In the study of 2023, Cerezo et. al., explores the global waste management problem, with a specific emphasis on the challenges faced in the Philippines, particularly at Taysan. The municipality was continuously reported due to various solid waste management problems. The invention of the electronic segregation machine was prompted by the obvious issues in the locale. Traditional trash segregation techniques frequently rely on labor-intensive, time-consuming, and error-prone manual sorting. This inefficiency may have a negative impact on recycling efforts and lead to incorrect trash management. Without effective segregation, recyclable materials may be contaminated by non-recyclable garbage.

The Electronic-Material Recovery Facility (E-MRF) functions by automating the waste segregation process through a combination of mechanical and electrical components. A detection mechanism, often using aluminum foil-coated paper, identifies the materials by completing an electrical circuit upon contact. Subsequently, the machine activates mechanisms like DC motors to sort the materials based on predefined criteria. The sorted materials are then moved along conveyor belts or platforms to separate them into distinct categories such as paper, plastic, or metal. Furthermore, the study on Electronic-Material Recovery Facilities (E-MRFs) highlights their potential to improve waste management practices. However, further research is needed to address several key areas, including technical design, impact on waste management skills, public awareness and education, and long-term sustainability. Addressing these issues could optimize E-MRFs and promote their wider adoption as a sustainable solution for waste management.

Thus, the study "RE-TAPON: Recycling Engine - Trash Automaton Promotes Optimal Recycling and Nurtures Waste Management Practices among Senior High School." aims to enhance the features of waste segregation machine with the integration of electronic technology and solar energy, for the purpose of making the RE-TAPON system automate the waste segregation process, making it more convenient and encouraging an active participation from students from Taysan Senior High School for them to improve their waste segregation practices. This research is driven to test and evaluate the product RE-TAPON in terms of durability, functionality and usefulness. The justification for this study is crucial because it addresses the requirement for efficient and effective waste segregation, a crucial issue in waste management. The study lies in creating a practical solution that aligns with modern advancements, fostering a sense of responsibility among students for effective waste segregation practices.

Objectives of the Study

The main objective of the project is to provide an electronic-based machine for waste segregation that can improve such skills of students in Taysan Senior High School.

1. To explore the enhanced features and specifications of RE-TAPON in terms of;

    1.1 Materials used

    1.2 Sensor Technology

    1.3 Power source

    1.4 Design

2. To test and evaluate the product RE-TAPON in terms of;

    2.1 Functionality

    2.2 Durability

    2.3 Usefulness

3. To propose a program to maximize the usability of RE-TAPON relative to waste segregation practices among students.

Scope, Limitations and Delimitations

This study, entitled "RE-TAPON: Recycling Engine - Trash Automaton Promotes Optimal Recycling and Nurtures Waste Management Practice'' is specifically focused on the enhancement of features and specifications for recyclable materials only. The primary objective is to explore the integration of electronic technology and solar energy into the waste segregation machine. The research delves into various aspects, including the testing and evaluation processes employed by the experts to assess the durability, functionality, and overall usefulness of the RE-TAPON system. The investigation also involves a comprehensive examination of the materials used, sensor technology, power source (solar energy), and the overall design of the product. Furthermore, the study intends to develop a program based on its findings to maximize the usage of RE-TAPON. This study will be limited to Taysan Senior High School in Mahanadiong, Taysan, Batangas during the second semester of the school year 2023-2024

The research is designed to assess the waste management skills of students at Taysan Senior High School. By providing them with this system, the

study aims to test and evaluate the product RE-TAPON. The hands-on, technologically advanced tool is expected not only to simplify waste disposal but also to instill a sense of responsibility for environmental sustainability through the utilization of solar power. By aligning with modern advancements in waste management technology, the research aims to create a practical solution that encourages students to actively engage in responsible waste management practices. Furthermore, the study incorporates specific limitations regarding the types of materials accepted by the RE-TAPON system. In the plastic bottle compartment, while the machine primarily accepts plastic bottles, it will also recognize other plastic materials for proper disposal, provided they are composed of plastic material. Additionally, in the paper compartment, paper materials must be folded at least four times to be accepted by the machine. These limitations are integral to maintaining the efficiency and functionality of the recycling machine while promoting responsible waste management practices among users.

Significance of the Study

The significance of this research lies in the development of a solar-powered electronic machine designed for waste segregation at Taysan Senior High School. This innovation is valuable in many ways and will benefit a certain beneficiaries:

School. The project makes handling waste at school fun and eco-friendly, using an innovative approach to waste management.

Administrators. This study offers a budget-friendly solution for school administrators to enhance waste management by efficiently addressing waste segregation and disposal challenges.

Parents. Enrolling children in the school ensures parents that their kids are learning practical skills, like responsible waste segregation practices, fostering a healthier and organized school environment.

Students. Students benefit from the RE-TAPON research by simplifying waste segregation, saving time, enhancing productivity, and fostering important separation skills, ultimately creating a cleaner and more orderly school environment.

Researchers. The study creates opportunities for researchers by leveraging the RE-TAPON program, potentially securing funding from environmental or government agencies, and offering a valuable reference for future waste segregation technology projects.

Future Researchers. The study provides a solid foundation and reference for future researchers in waste management, offering valuable insights for those interested in developing RE-TAPON or working in related fields.

Definition of Terms

The following terms are defined conceptually and operationally to provide a clear distinction of the words used in this study.

Automaton. This is an abstract model of machines that perform computations on an input by moving through a series of states or configurations. (Basics of

Automata Theory, n.d.) In this study, it refers to the automaton as the RE-TAPON machine itself.

Engine. It is a machine that burns fuel and converts it into mechanical power. (Hinderer & Hinderer, 2024). In this study, it refers to the RE-TAPON machine as a special engine that uses stored solar energy to do work.

Paper. A material platform for novel devices in diagnostics, microfluidics, and electronics, due to its unique properties. (Rolland & Mourey, 2013). In this study, it refers to the used sheet that is mostly school-related works that is no longer used.

Plastic bottle. They are ubiquitous and the most commonly used container for liquids (SMF, 2023). In this study, it refers to a plastic bottle that is classified as an insulator of electricity that distinguishes it from a tin can that is a conductor of electricity.

Recyclable Materials. These are used or old materials that can be used to make some other materials.(Rinkesh, 2022). In this study, it refers to the use of recyclable materials as the main part of a machine designed to efficiently separate and collect recyclables.

Recycling. The process of converting waste products into reusable materials. (Shaw, 2018). In this study, it refers The RE-TAPON machine is designed to separate the recyclables to be recycled.

Solar Energy. The cleanest and most abundant renewable energy source available.(About Solar Energy | SEIA, n.d.). In this study, it refers to solar energy

as the main power source of the machine which is being stored in a battery that will make the machine work anywhere.

Tin Can. This is an aluminum container or a tinplate that is commonly used for preserving or packaging food, beverages, oil, chemicals, etc.(Minjia, 2021). In this study, tin cans are classified as a conductor of electricity that distinguishes them from plastic bottles that are an insulator of electricity.

Waste. It is everything that no longer has a use or purpose and needs to be disposed of. (American Veterinary Medical Association, n.d.). In this study, it refers to waste materials such as paper, bottles, and cans that are no longer in use and can potentially be recycled and separated through the utilization of the RE-TAPON machine.

Waste Management. It is a streamlined process that organizations use to dispose of, reduce, reuse, and prevent waste.(Safety Culture, 2023). This study assesses students proficiency in waste management and their knowledge of separating waste, particularly recyclables, through the utilization of the machine.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter of the paper presents the conceptual and related literature, synthesis, the conceptual framework, and the research hypotheses.

Conceptual Literature

Key areas covered in this conceptual literature include waste management, recycling, its process, its importance, the smart trashcan and its sustainability. The information contained in this conceptual literature ranges from 2019 to 2023.

Waste Management. The world generates 2.01 billion tonnes of municipal solid waste annually, with at least 33 percent of that—extremely conservatively—not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms. Though they only account for 16 percent of the world's population, high-income countries generate about 34 percent, or 683 million tonnes, of the world's waste (*Trends in Solid Waste Management*, n.d.).

Recycle. Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. Recycling can benefit your community, the economy, and the environment. Products should only be recycled if they cannot be reduced or reused. Many people are confused about what items can be recycled, where they can be recycled and how. This often leads to recyclables going in the trash or trash going in the recycling bin. (*Recycling Basics and Benefits | US EPA*, 2023)

Recycling in School. As schools help to shape the habits that we continue into adulthood, children who participate in recycling now will learn about the benefits of carrying on this "habit" as adults. Teaching children about recycling exposes them to various learning opportunities, including ecosystems and material properties. It instills ethical citizenship by showing kids that their small actions matter for sustainability. Recycling also sparks creativity in children, allowing them to make art and projects from recycled materials without excessive spending.(Lee, 2023)

Smart Trash Can. According to Gyanchandani (2023) in today's rapidly advancing technological era, even the most mundane aspects of our lives are undergoing revolutionary changes. Waste management, a critical yet often overlooked facet of modern society, is no exception. Introducing the era of smart bins—a technological marvel poised to revolutionize the way we handle waste. These intelligent waste containers are equipped with sensors, connectivity features, and data analytics capabilities, empowering municipalities and businesses to optimize waste collection, reduce costs, and minimize environmental impact.

Sustainability of the Machine. According to Maka and Alabid (2022) solar energy is environmentally friendly technology, a great energy supply and one of the most significant renewable and green energy sources. It plays a substantial role in achieving sustainable development energy solutions. Therefore, the massive amount of solar energy attainable daily makes it a very attractive resource for generating electricity.

Related Studies

In this section, a diverse array of readings and literary works supporting the main topic is presented. Insights have been drawn from various sources and related studies by the researchers. The exploration commences with a thorough examination of the definition and various factors contributing to the functionality of a smart trash can.

In the study conducted by Cerezo et. al. (2023) focused on developing an Electronic-Material Recovery Facility (E-MRF) , a functional segregation machine constructed using affordable materials to enhance waste segregation skills among students. The researchers aimed to automate and improve the efficiency of waste segregation processes by implementing the E-MRF system. Data collected from students in various academic strands indicated a positive reception of the E-MRF, particularly in terms of productivity and eco-friendliness. The system integrated mechanical forces, electrical circuits, and material behavior to detect and regulate waste segregation effectively. The study emphasized the significance of efficient waste segregation for environmental sustainability and proper waste management practices. Considering the research findings, integrating a functional segregation machine like the E-MRF is crucial for improving waste segregation skills and addressing ecological issues for a sustainable environment.

According to the study of Aqilah et al. (2021) on the smart trash can, a groundbreaking innovation in the realm of automatic waste disposal designed to facilitate the segregation of diverse waste categories. The study highlighted the pervasive nature of garbage in our daily lives, which frequently leads to

widespread consequences. The importance of the topic is that it focuses on the smart trash can, which is a significant innovation in waste disposal. In this study, an experimental research was made in order to create a trash bin that will automatically segregate different wastes. This technology helps to separate different types of waste efficiently, which is crucial for environmental and hygiene reasons. As a result, Aqilah et al. succeeded in a study to create a thing that will help the community to separate different kinds of wastes. In conclusion, the Smart Trash Can not only promises to catalyze innovation in the realms of industry and technology but also stands as a crucial instrument in elevating public consciousness and knowledge surrounding environmentally responsible waste management, aligning with the global efforts laid out in the Sustainable Development Goals.

A comprehensive review by Li et al. (2020) explored the environmental benefits of solar energy adoption, emphasizing its role in mitigating greenhouse gas emissions and combating climate change. The study provided insights into the life cycle assessment of solar panels and their overall environmental impact, contributing valuable information for policymakers and stakeholders interested in promoting sustainable energy solutions. Their research delved into the economic factors influencing the adoption of solar technologies, including government incentives, financial models, and market dynamics. The study emphasized the importance of supportive policies in fostering the widespread integration of solar energy systems.

In the study of Johnson et. al. (2019) explores the economic viability of integrating solar technology into smart trash bin operations, emphasizing the

decreasing costs associated with solar panel installations. These findings underscore the increasing affordability of solar-powered smart trash bins, driving their widespread adoption in waste management systems. Additionally, the research addresses the environmental benefits, emphasizing a reduction in carbon footprint and decreased dependence on non-renewable resources. In conclusion, the study highlights the dual advantages of economic feasibility and environmental sustainability, positioning solar-powered smart trash bins as a promising solution to enhance waste management practices.

Renewable energy sources, particularly solar energy, have gained significant attention due to their potential to address environmental concerns and meet the growing global energy demand. In their study, Wang and Zhang (2019) highlighted the rapid advancements in solar photovoltaic (PV) technology, emphasizing its role in harnessing clean and sustainable energy. The authors discussed the efficiency improvements and cost reductions in solar PV systems over the years, making solar energy an increasingly viable option for mainstream electricity generation.

Furthermore, A study highlights the considerable potential of solar energy to power smart trash bins, offering a clean and sustainable energy source. Solar panels, also known as photovoltaic (PV) cells, are integral to this research, with a focus on advancements in materials and design to enhance the efficiency of solar-powered smart trash bins. (Smith and Jones, 2018, as cited in Smith et. al., 2021)

Synthesis

The conceptual literature highlights the global challenge of handling solid waste and the imperative for environmentally safe practices. A recurring theme is the transformative approach of recycling, not merely as waste disposal but as a pathway to sustainable living. Automated smart bins, a groundbreaking innovation, use sensors, connectivity, and data analytics to optimize waste collection, reduce costs, and lessen environmental impact, a point emphasized by Gyanchandani (2023) and Aqilah et al. (2021). The literature also underscores the role of schools in shaping recycling habits, as noted by Lee (2023), and the success of automated waste segregation systems in improving waste management skills among students, as seen in Cerezo et al. (2023).

On the other hand, the studies converge on the importance of recycling and technological innovations, their focus areas differ. Lee (2023) emphasizes the role of schools in instilling environmental awareness and ethical citizenship, highlighting economic benefits and fostering a sense of responsibility among students. In contrast, Maka and Alabid (2022) extend the discourse to renewable energy, specifically solar energy, emphasizing its role in providing clean, sustainable electricity and its potential for cost reduction and environmental benefits. The studies by Smith and Jones (2018), Wang and Zhang (2019), and Li et al. (2020) further explore advancements in solar technology and its efficiency improvements.

The uniqueness of the current study lies in its comprehensive approach, integrating the themes of waste management, recycling, smart trash cans, and sustainability. The focus on enhancing the features of the RE-TAPON project by

utilizing solar panels to improve efficiency and lifespan, and fostering responsible waste disposal habits among students at Taysan Senior High School, sets it apart. This study aims to bridge technological innovations with educational initiatives, highlighting the interconnectedness of waste management practices, technological advancements, and renewable energy solutions, and calling for a collective effort to address global waste management challenges.

Conceptual Framework

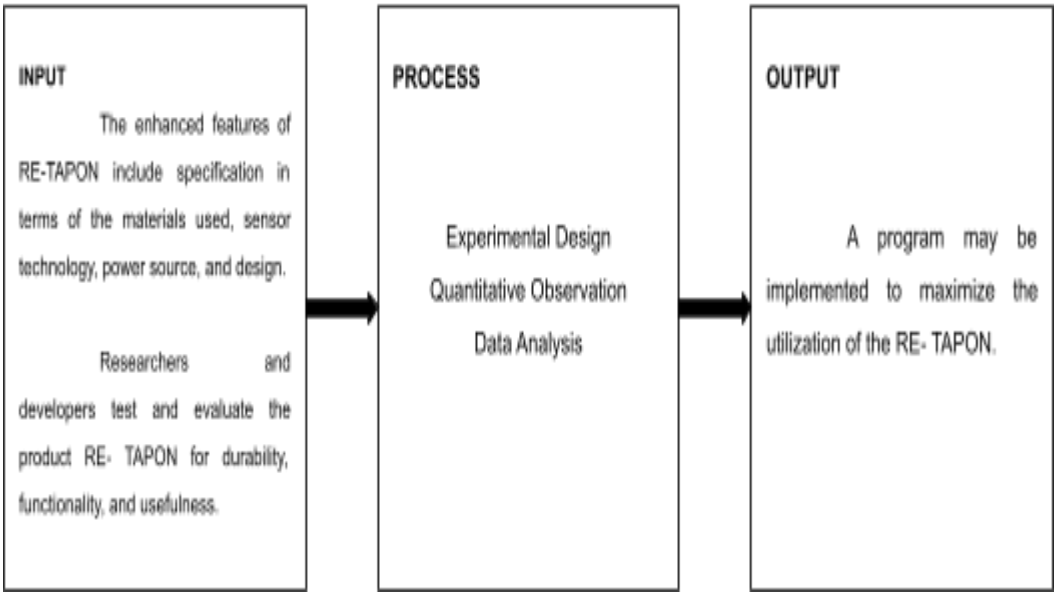


Figure 1. Research Paradigm

The researcher adopted the Input Process Output (IPO) model. It includes all of the information that is required in the process and the specific details of the process itself. The concept model, as shown in Figure 1, shows what is the process of providing an electronic waste machine for better waste segregation skills of the students in Taysan Senior High School.

For input, it consists of enhancing the features of RE-TAPON and its specifications in terms of materials used, sensor technology, power source and design. It also consists of how experts test and evaluate the product RE-TAPON in terms of durability, functionality and usefulness. Usually, all the details specified in the statement of the problems are stipulated here. For the process, it includes experimental design, quantitative observation and data analysis. For output this includes the action taken after interpreting the results of the study. Action plan, recommendation and other related things taken for consideration. From this, the researchers conceptualized recommendations to maximize the utilization of the RE-TAPON to improve the waste segregation skills of the students in Taysan Senior High School.

CHAPTER III

RESEARCH METHODS AND PROCEDURES

This chapter of the paper presents research design, pre-design and design stage of the project, tool, equipment and their functions, supplies and materials, testing stage, time allocation, financial components, instrumentation and sampling techniques.

Research Design

This research employs experimental research design. Experimental research is a study conducted with a scientific approach using two sets of variables. The first set acts as a constant, which you use to measure the differences of the second set (Bhat, 2023). It is applicable to this study because it allows for the systematic testing and evaluation of the durability, functionality and usefulness of RE-TAPON (Recycling Engine - Trash Automaton Promoting Optimal Recycling and Nurtures waste management skills.). This method provides a structured quantitative observational approach to understanding the product RE-TAPON.

Pre- Design Stage of the Project

The RE-TAPON initiative, focused on creating a smart trash bin for sustainable waste management, aligns with its primary goal of contributing to the attainment of Sustainable Development Goals (SDGs). By addressing the prevalent issue of inefficient waste segregation, the project introduces an innovative solution that integrates various technological devices into the smart

trash bin. Specifically, the project aims to provide an electronic-based machine for waste segregation to enhance the skills of students at Taysan Senior High School. The key features and specifications of RE-TAPON include materials used, sensor technology, power source, and design improvements. The researchers and developers will conduct testing and evaluation of RE-TAPON, considering aspects such as durability, functionality, and usefulness. Additionally, a program may be implemented to maximize the usability of RE-TAPON, emphasizing its potential impact on technology adoption and responsible waste disposal practices among users, particularly students.

The highlighted issue is caused by ineffective waste segregation, which poses environmental issues, as well as a general lack of knowledge and enthusiasm about technology, particularly among students. The suggested remedy is to design a smart trash can that doubles as a teaching tool in addition to facilitating appropriate waste segregation through the use of sensors and technology. Thus, the project's goals are creating an interactive trash disposal system and encouraging students' interest in technology and knowledge of waste segregation techniques.

The target users for the RE-TAPON project are students across various educational levels. The anticipated outcomes include the development of interest in technology and the imparting of knowledge regarding proper waste segregation. To ensure the success of the project, specific design requirements have been outlined, encompassing functionality, usability, and essential features. Notable features include the use of solar panels for sustainable energy, real-time monitoring of waste levels, and an integrated educational content display.

In anticipating potential risks, the project identifies technical malfunctions, limited user interest, and dependence on solar panels as potential challenges. Strategies to mitigate these risks involve regular maintenance, user engagement initiatives, and the inclusion of a secondary power source for periods of low sunlight. Ethical considerations, such as privacy, accessibility, and unbiased educational content, have also been integrated into the project's framework.

Comprehensive documentation is a crucial aspect of the pre-design stage, capturing detailed project overviews, design rationales for chosen technologies, risk mitigation strategies, and ethical guidelines. Through this well-structured pre-design approach, the RE-TAPON project seeks to emerge as a sustainable, innovative, and educational solution for waste management, aligning with its overarching goal of engaging and educating students in technology and responsible waste disposal practices.

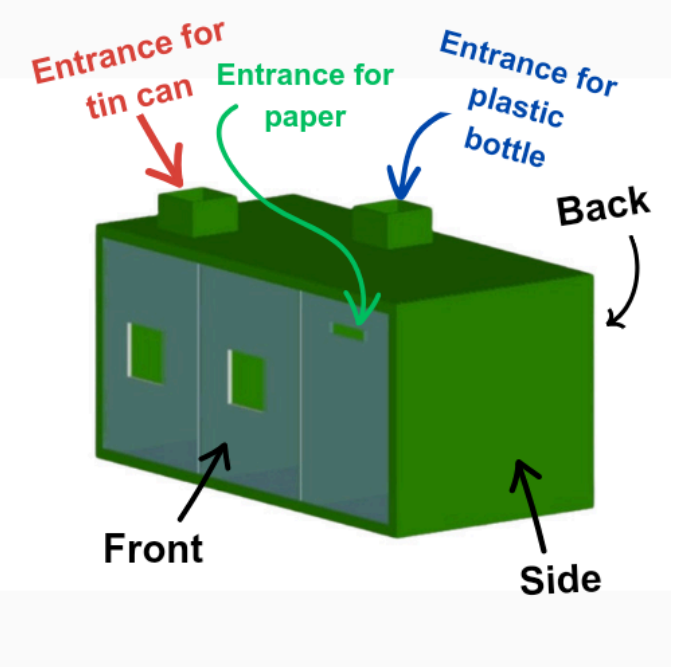


Figure 2. 3D Models

The figure above shows the 3 dimension model of the project. This is a three in one smart trash bin made of a composite material. The illustration above will serve as a guide that needs to be made in order to accomplish the project.

Note: All of the measurements are in inches.

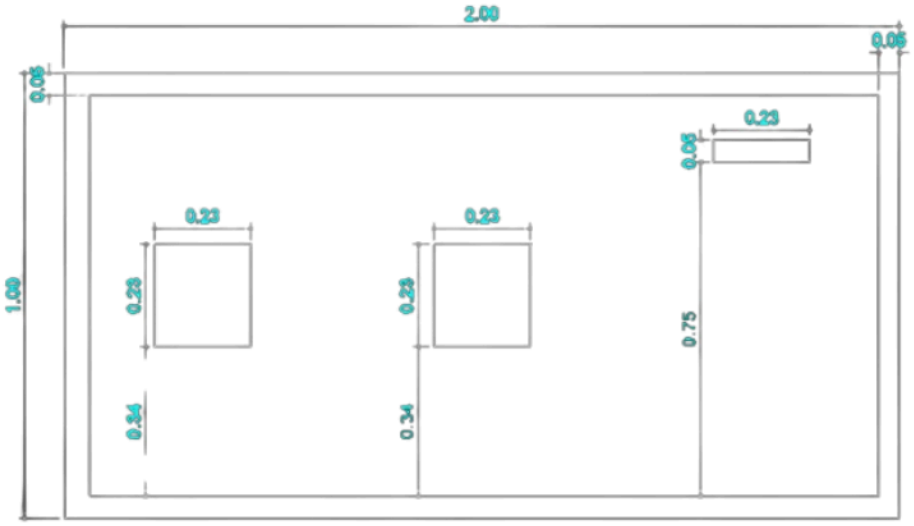


Figure 3. Front Side View

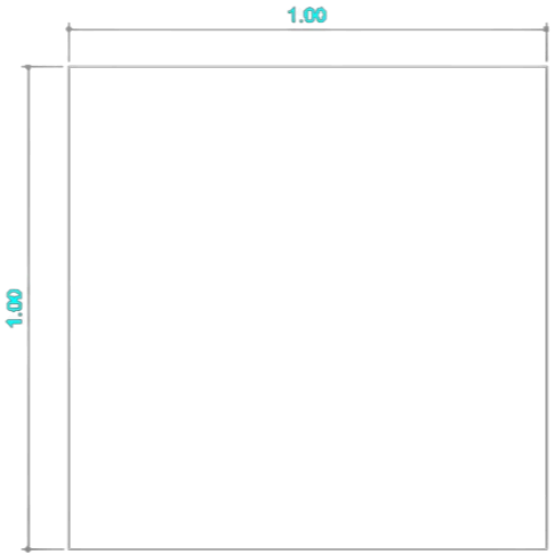


Figure 4. Left and Right Side View

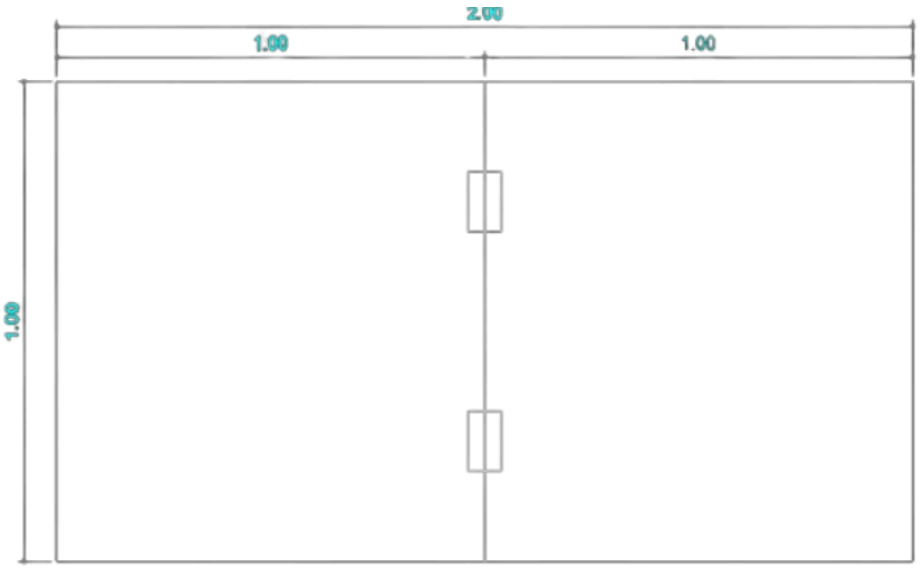


Figure 5. Back Side View

Figure 6. Bottom Side View

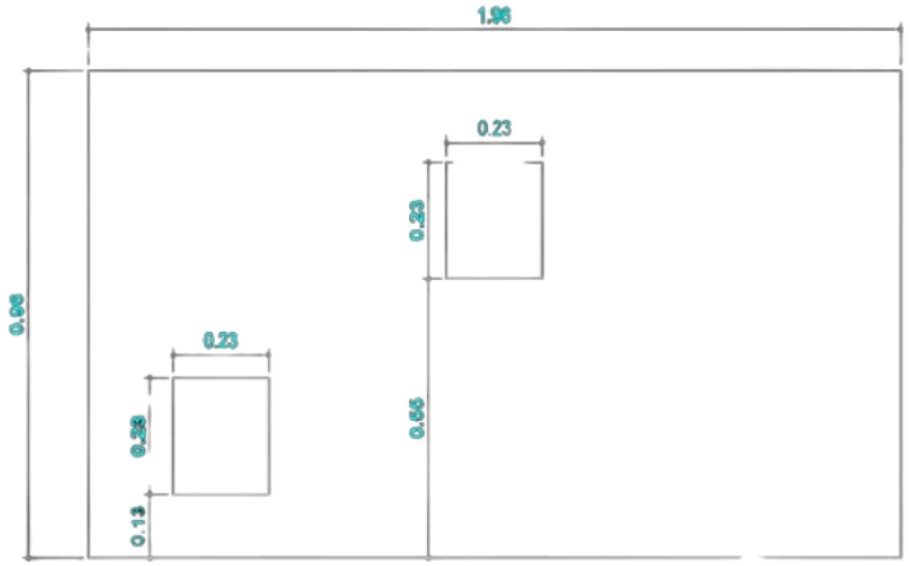


Figure 7. Top Side View

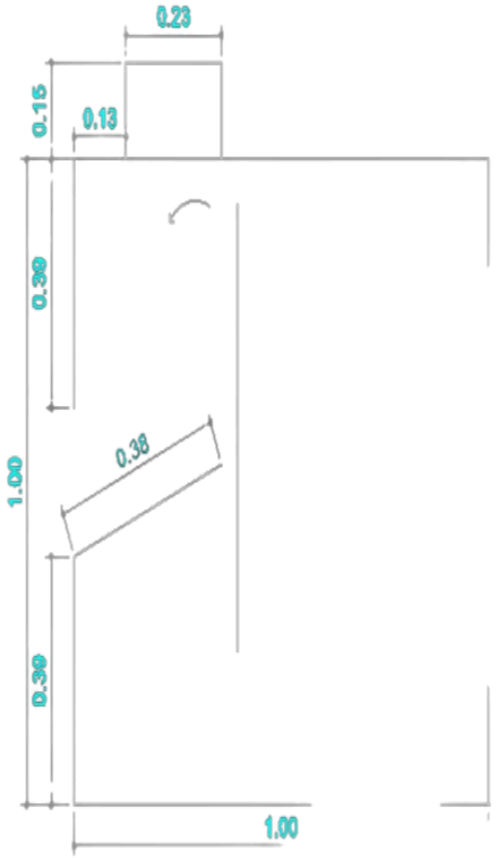


Figure 8. Can Side View

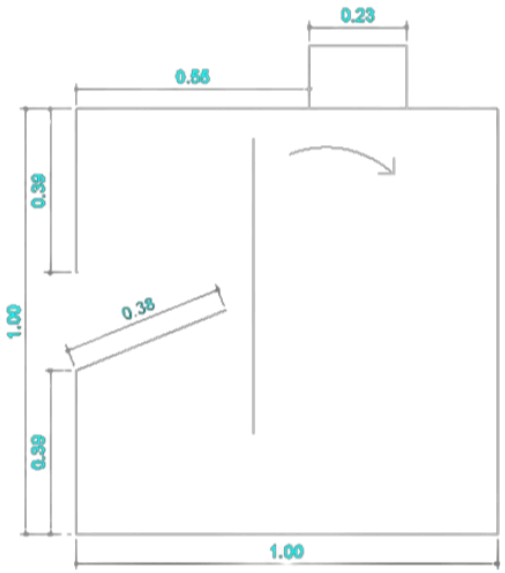


Figure 9. *Bottle Side View*

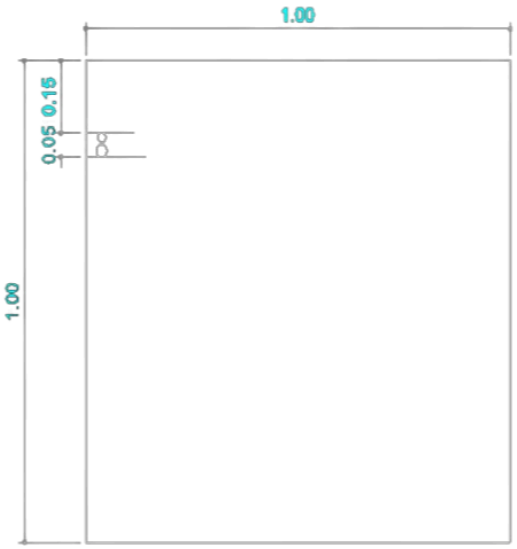


Figure 10. Paper Side View

Figures 2 to 10 display various aspects of the project, including measurements and dimensions, providing a detailed visual representation that aids in understanding its different elements. Analyzing these numbers reveals crucial insights into the project's intricacies, facilitating improved planning and decision-making processes. The inclusion of precise measurements ensures

accuracy and clarity, enabling researchers to grasp the size and complexity of each component. These visual aids serve not only to enhance researchers' comprehension but also to guide the implementation process effectively.

Design Stage of the Project

The RE-TAPON project aims to tackle the issue of inefficient waste segregation at Taysan Senior High School by introducing a smart trash bin. This electronic-based machine enhanced students' waste segregation practices through features like high-quality materials, advanced sensors for accurate waste detection, solar panels for sustainable power, and a user-friendly design. Rigorous testing will be conducted to ensure durability, functionality, and overall usefulness. To maximize impact, a program will guide students in effectively using the smart trash bin. The overarching goal is to create an interactive and educational solution, fostering technology interest and promoting responsible waste disposal. The project considers potential risks, emphasizing ethical considerations. Through comprehensive documentation, RE-TAPON aims to be a sustainable and innovative initiative, contributing to waste management while engaging and educating students in technology and responsible waste disposal practices

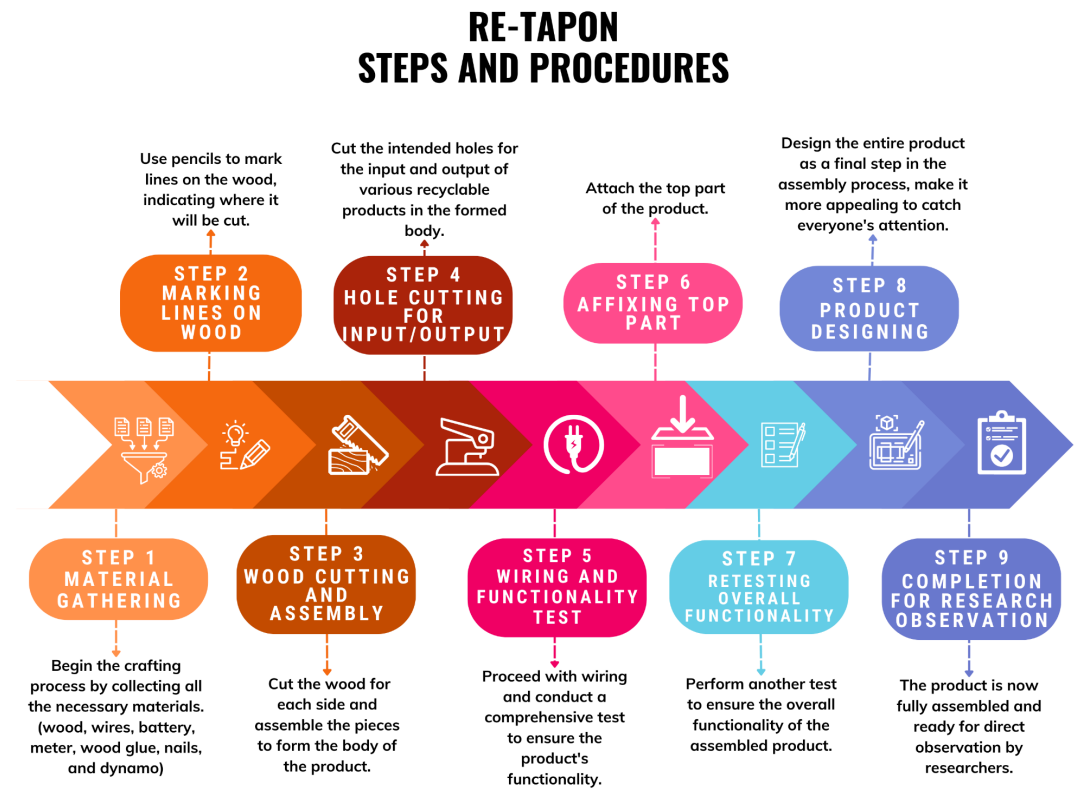


Figure 11. Steps and Procedure

Timeline

The development process for the RE-TAPON project can be structured as follows:

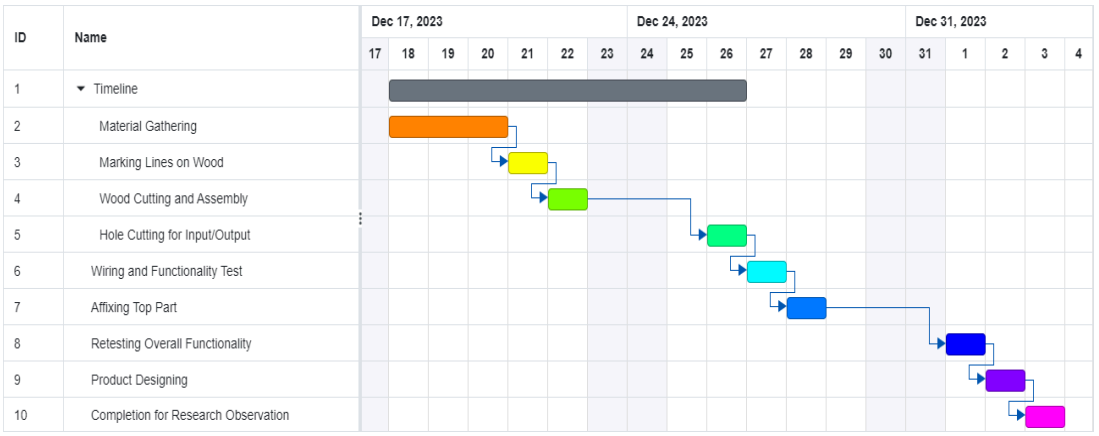


Figure 12. Timeline Chart

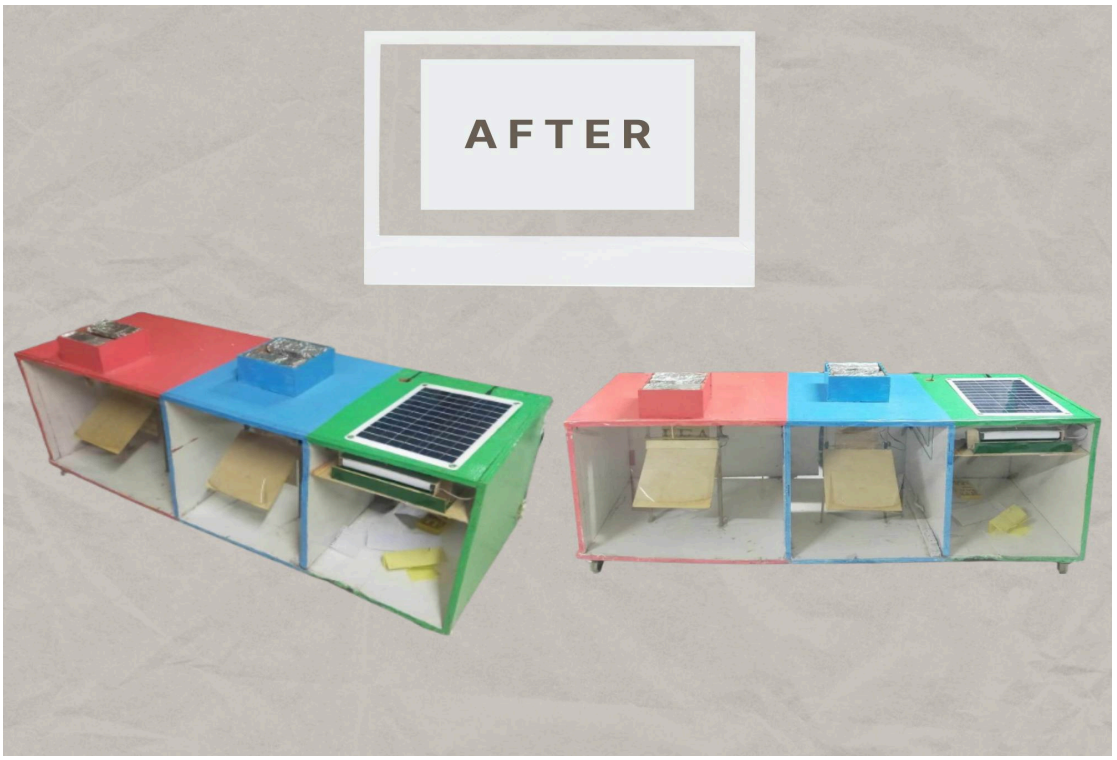
This structured timeline outlines each stage of the development process, indicating the specific activities to be undertaken on each day.

Throughout the development process, ethical considerations should be paramount. Ensure that the materials used are ethically sourced and environmentally friendly. Additionally, the hole cutting for input/output should be designed to prioritize user safety and prevent accidents. During the wiring and functionality test, respect privacy and confidentiality, especially if personal data is involved. In the product design phase, adhere to principles of inclusivity and avoid creating designs that may perpetuate biases. Finally, during research observation, obtain informed consent from participants and ensure that their rights are protected. Regularly review and update the ethical guidelines to align with evolving standards.

Documentation


Material Gathering
Cutting of woods
Assembling of frame
Painting of the prototype
The Prototype
Assembling of the top part


Retesting Overall Functionality
Removal of the front part
DURING
Painting the body
Fixing the wirings inside the product
Attaching the wheels
Hole cutting for input/output



Tools, Equipment, and their Functions

This section contains the compilation of tools and equipment used to complete this project.

Table 1.

Tools and Equipment

Item	Category	Description	Function
Dynamo 	Tools	Generates electrical power through mechanical means, often used in small-scale electricity generation.	A dynamo is a device that converts mechanical energy into electrical energy. In this project, the dynamo was used as a rotating device to move the segregation board depending on its terminals.
Foil 	Tools	Thin metal sheet, commonly used for wrapping food, crafting, or as a heat insulator.	Foil is used as a sensor in this project. Because of its ability to conduct electricity, this is used as connecting material.
Wires 	Tools	Conductive strands used to transmit electrical signals or power between components.	Wires serve as pathways for the flow of electricity in various devices such as this RE-TAPON project.

Item	Category	Description	Function
Wood 	Equipment	A panel made of layers of wood veneer glued together, versatile in construction and woodworking.	Wood serves as the structural material for constructing the body of the smart trash bin. It provides durability and stability, supporting the internal components and ensuring the longevity of the device in different environmental conditions.
Solar Panel 	Equipment	Converts sunlight into electricity, typically composed of photovoltaic cells.	The solar panel is a key component aligning with the project's sustainability objective. It harnesses solar energy to power the RE-TAPON system, reducing reliance on conventional electricity sources and contributing to the overall eco-friendly design.

Item	Category	Description	Function
12V Battery 	Equipment	Stores electrical energy in a chemical form, commonly used in various applications such as automotive and renewable energy systems.	Acting as an energy storage solution, the 12V battery ensures continuous operation during periods of low sunlight. It stores excess energy generated by the solar panel, providing a reliable power source for the smart trash bin, even in less favorable weather conditions.
Glue Stick 	Tools	Adhesive in solid form, easy to apply for bonding paper, cardboard, and lightweight materials.	The glue stick is used for adhesive purposes in securing components and materials together during the assembly of the smart trash bin. Its application ensures structural integrity and prevents disintegration of the various parts over time.

Item	Category	Description	Function
Steel Hinge 	Tools	Joint mechanism made of steel, facilitating the movement of doors, lids, or other objects.	The steel hinge facilitates the movement of the smart trash bin's lid, enabling easy disposal of waste by users. Its robust construction ensures durability, and proper installation allows for smooth and controlled lid operation.
Wheels 	Equipment	Circular components rotating on an axle, often used for mobility in vehicles or machinery.	Wheels are incorporated into the design for mobility, allowing the smart trash bin to be easily maneuvered to different locations. This feature enhances the accessibility and adaptability of the RE-TAPON system within diverse educational environments.

Item	Category	Description	Function
Screw Driver 	Tools	Hand tool designed for turning screws or bolts.	The screwdriver is essential for assembling and disassembling components, providing a versatile and straightforward tool for securing fasteners and making adjustments during the construction of the RE-TAPON smart trash bin.
Barbeque Sticks 	Tools	Barbecue sticks, also known as skewers or kebab sticks, are slender and elongated rods typically made of metal, wood, or bamboo.	In this project, barbecue sticks are used as supporting material that will hold the board and motor.

Supplies and Materials

Table 2.

Supplies and Materials

Item	Quantity	Description
Plastic cover	1 ½ Yards	The plastic cover is used to shield an object from dust, spills, or damage specifically employed to protect the smart trash bin. It is also utilized to observe what is happening inside and how it operates, aiming to encourage the students to use it more effectively.
Wood	2	Wood serves as the structural material for constructing the body of the smart trash bin. It provides durability and stability, supporting the internal components and ensuring the longevity of the device in different environmental conditions.
Glue Stick	12	The glue stick is used for adhesive purposes in securing components and materials together during the assembly of the smart trash bin. Its application ensures structural integrity and prevents disintegration of the various parts over time.
Paint	1 Green 1 Black	Paint serves both functional and aesthetic purposes, providing a protective layer for the plywood against environmental factors while also allowing for customization and branding. It contributes to the overall visual appeal of the RE-TAPON smart trash bin.

Item	Quantity	Description
Nails	¼	Nails are essential fasteners used in construction and carpentry. Their primary purpose is to securely join materials, such as wood, by penetrating and holding them together. In the context of our product, the smart trash bin RE-TAPON, nails play a crucial role in reinforcing its structure. This ensures that the smart trash bin is sturdy and durable, capable of withstanding regular use while maintaining its functionality and form.

Testing Stage

In this study, during the testing phase, the researcher creates a detailed plan to carefully watch and assess the RE-TAPON product. This plan focuses on figuring out how well the product works, how long it lasts, and how useful it is, especially in dealing with waste separation. Before using this plan, it goes through a check by a research advisor to make sure it's good and fits the goals or objectives of the study. Once it gets validated, the researchers put the plan into action, observing how they will interact with the RE-TAPON to gather specific information about waste separation. After this watching period, the researchers analyze the collected data using math methods to see how effective RE-TAPON is at improving waste segregation skills. They will also gather comments and suggestions to make the product even better. Throughout this process, they're careful to deal with challenges like potential biases, making sure the data is accurate, handling logistical problems, and keeping participants engaged.

Time Allotment

Date	**Activity**
December 4 - 13	Writing of Chapter 1 - 3
December 14 - January 6	Product Making
January 7 - 10	Revision of Chapter 1 - 3
January 10 - 11	Construction of Quantitative Observation
January 12 - 17	Testing and Evaluation
January 16 - 21	Writing of Chapter 4 - 5
January 22 - 25	Revision

Financial Components

Table 3. Material Cost

Item	**Cost**
3V Dynamo	PHP 25.00
Foil	PHP 60.00
Wires	PHP 50.00
Wood	Donated
Solar Panel	PHP 600.00
12V Motor Battery	Donated
Glue Stick	PHP 5.00
Paint	PHP 100.00
Total	**PHP 840.00**

Instrumentation

In this study, researchers employ quantitative observations as the primary method for data collection to explore potential programs for implementing the RE-TAPON machine and enhancing student's waste segregation skills. The experts evaluated the RE-TAPON machine's durability, functionality and usefulness, providing hands-on insights into its possible impact on student's practical application of waste management skills. The instruments used include quantitative observations, where researchers focus on recording interactions with the RE-TAPON machine, emphasizing its effective and efficient use in waste management tasks. This approach allows for a direct measurement of the tool's influence on students' performance in applying waste management skills.

According to Tegan George (2023), Quantitative observation is a research method that involves measuring and quantifying characteristics of a phenomenon. It hinges upon gathering numerical data, such as measurements or counts, that can be expressed in terms of a quantitative value.

The experiment is the explanatory research method in which the researcher intervenes in the sample deliberately imposing the levels of one or more explanatory characteristics on its units with the purpose of generating inferences about the causal effects of these characteristics on response characteristic. These are extrinsic or treatment characteristics. Corrêa da Silva(2022).

CHAPTER IV

PRESENTATION, AND INTERPRETATION and ANALYSIS OF DATA

1. The enhanced features and specifications of RE-TAPON

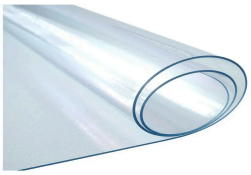
The RE-TAPON has undergone significant enhancements to improve its functionality, durability and usefulness. Its lower frame structure makes it more accessible to everyone, while the larger compartment allows for the storage of more trash. The transparent front view enables users to see the trash they input, promoting awareness and accountability. Integration with solar panels ensures sustainable energy use. The sturdier frame, constructed with plywood, enhances durability, and the addition of a resistor improves operational efficiency. Enlarging the hole facilitates the disposal of larger items like cans and plastic bottles. Aesthetic improvements include painting it with more pleasing colors which are pastel red, pastel blue and pastel green, while the addition of wheels enhances mobility. Clear instructions make it more user-friendly, and the cabinet-type door provides easy access to deposited trash. These enhancements collectively aim to foster a culture of recycling and responsible waste management among high school students.

1.1 Materials Used

Table 4.

Material Used

Materials	Description
12V battery 	A 12V battery is a type of electrical energy storage device that produces a direct current (DC) voltage of 12 volts. It is commonly used in various applications, including automotive systems. In this project, the battery was used as storage that will supply the whole bin.
Solar panel 	Solar panels, also known as photovoltaic (PV) panels, are devices that convert sunlight into electricity. This material was used to harvest solar energy that will power the project.
Dynamo 	A dynamo is a device that converts mechanical energy into electrical energy. In this project, the dynamo was used as a rotating device to move the segregation board depending on its terminals.
Foil 	Foil, commonly known as kitchen foil or aluminum foil, is a thin, versatile sheet made of aluminum metal. It is used as a sensor in this project. Because of its ability to conduct electricity, this is used as connecting material.
Wires 	Wires are conductive strands typically made of metal, such as copper or aluminum, used to carry electrical signals or transmit power. They serve as pathways for the flow of electricity in various devices such as this RE-TAPON project.
Wood 	Wood is a versatile material that has been widely used by humans for various purposes, including construction, furniture making. In this project, wood was used as the bins' outer case and dividers.

Materials	Description
Plastic Cover 	A thick plastic cover typically refers to a sturdy and durable sheet or layer made of plastic material that is notably thick. These are used as cover to the front case to have a transparent front view.
Paint 	Paint is a liquid substance, typically composed of pigments suspended in a vehicle, such as oil or water, used for coating surfaces to impart color, protection, and texture. Paint serves as outer protection of the bin and to attract the users.
Wheels 	Small wheels are compact and relatively diminutive cylindrical structures designed to facilitate motion or rotation in various mechanical systems. Typically, these wheels are used to reduce friction and enable smoother movement, commonly found in applications such as carts. This was used and attached to the bin to move the bin easily from one place to another.
Cardboard 	Cardboard is a versatile and lightweight material commonly used for packaging and construction. It is made from layers of paperboard or corrugated paper that are glued together, providing strength and durability. This was used as a segregation board because it has a light mass and can rotate easily by low watts motors.
Barbeque Sticks 	Barbecue sticks, also known as skewers or kebab sticks, are slender and elongated rods typically made of metal, wood, or bamboo. In this project, sticks are used as supporting material that will hold the board and motor.
Plywood 	Plywood is a type of engineered wood panel made from thin sheets of wood veneer, known as plies or layers, which are glued together to form a strong and versatile material. This material was used in this project as supporting passage of the segregator.

This table illustrates the materials utilized by the project proponents to accomplish the RE-TAPON project. RE-TAPON is primarily constructed using foundational materials such as wood, motors, and battery. To address the project's modification requirements, the proponents have integrated a solar panel and charger system aimed at harvesting and storing solar power. Additionally, to enhance usability and aesthetics, the usage of paint, wheels, and plastic cover are emphasized, aiming to imbue the project with vitality and convenience for its user.

Hence, the proponents utilized solar panel because they found out in the study of Smith and Jones (2018) cited in the study of Smith et. al. (2021) that there is considerable potential of solar energy to power smart trash bins, offering a clean and sustainable energy source. Likewise, solar panels, also known as photovoltaic (PV) cells, are integral to this type of research, with a focus on advancements in materials and design to enhance the efficiency of solar-powered smart trash bins, as investigated by scholars like Johnson et al. (2019). The previous study explores the economic viability of integrating solar technology into smart trash bin operations, emphasizing the decreasing costs associated with solar panel installations. These findings underscore the increasing affordability of solar-powered smart trash bins, driving their widespread adoption in waste management systems which are highly relevant to the current study.

Indeed, the primary goal of this project is to modify the existing smart trash bin by using high quality materials and a sustainable source of power. The use of solar panels and charger are highlighted as it converts the machine from

an independent and limited Direct Current (DC) power source into a sustainable and renewable solar powered source. Other modifications such as the usage of woods and clear plastic are part of the project, it is inspired by the collaborative idea of the present research.

1.2 Sensor Technology

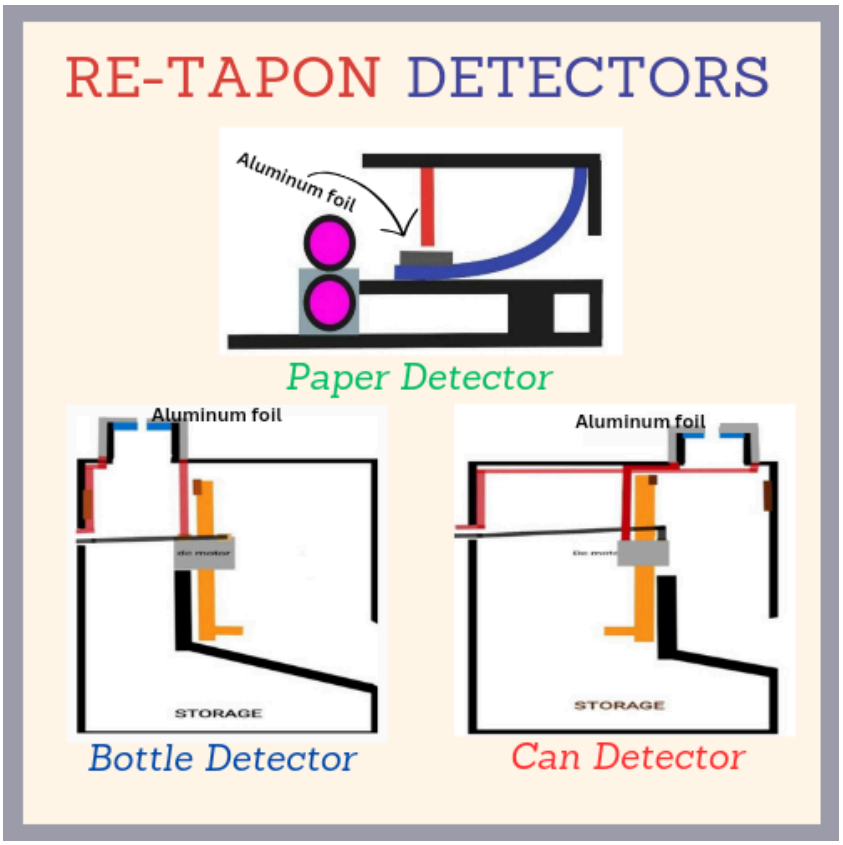


Illustration from Electronic- Material Recovery Facility Utilization

Figure 13. *RE-TAPON Sensors*

The figure shows the visual product design in terms of sensor technology in this product. In the RE-TAPON project, aluminum foil serves as a detector mechanism. Within the paper compartment, a layer of aluminum foil is placed on a paper surface, with a wire connected to the Direct Current Motor. At the top of the paper, another wire is connected to the battery. When the paper is inserted,

the aluminum foil and wire make contact, allowing electricity from the battery to flow. This action activates the DC Motor, which then pulls the paper inside.

For the entrance points where cans or plastic bottles are dropped, holes are drilled in the machine casing at the top. These holes are filled with foam, which has aluminum foil attached to it. The foam ensures the aluminum foil returns to its position and remains undamaged. The aluminum foil acts as a conduit for electricity and is connected to the DC motor which has a plywood attached to it and acts as a segregator for plastic bottles and cans. The principles of electrical conductivity and circuits are fundamental to this setup.

According to the study of Cerezo et. al. (2023) the detector used within the Electronic-Material Recovery Facility (E-MRF) utilizes aluminum foil-coated paper to detect the presence of materials such as paper, plastic bottles, or tin cans. When these materials come into contact with the aluminum foil-coated paper, an electrical circuit is completed, allowing electricity to flow and triggering the operation of components like a DC motor or battery. This setup showcases the detector's sensitivity and precision, as even a slight contact with the aluminum foil-coated paper can initiate the flow of electricity, enabling the E-MRF to efficiently identify and respond to the materials being sorted.

The RE-TAPON project's sensor technology showcases a commendable integration of electrical conductivity and circuit principles into waste segregation, using aluminum foil as a cost effective detector mechanism. The integration of aluminum foil-coated paper and its connection to components like the DC (Direct Current) Motor and battery showcase a thoughtful yet straightforward implementation inspired by Cerezo et al. (2023). The drilling of

holes in the machine casing for material entry points, filled with foam equipped with aluminum foil, not only ensures the foil's protection but also highlights attention to detail in maintaining the conductivity required for the system. The overall design emphasizes the reliability and efficiency of the segregation process, aligning with the principles outlined in the E-MRF study and contributing to the advancement of automated waste segregation practices solutions.

1.3 Power Source

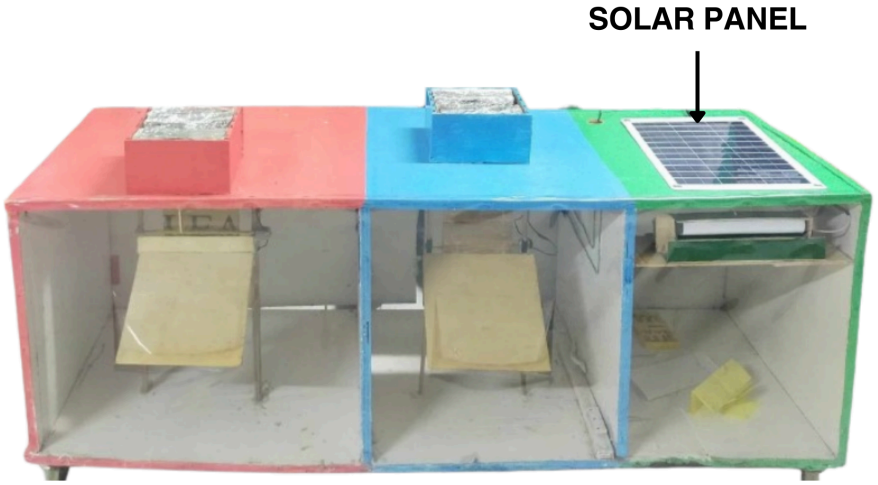


Figure 14. *RE-TAPON Power Source*

The RE-TAPON machine uses solar energy as its primary power source, this energy gets stored in a 12V motor battery. This battery acts like a backup, keeping the machine running smoothly even when there's not much sunlight. It saves extra energy from the solar panel, ensuring a steady power supply for the machine, even in not-so-great weather. The 12V battery is handy because it's small and can easily fit into the machine, making it portable. The 12V battery

provides a stable power output, keeping the machine's performance consistent and suitable for running the internal parts.

Several studies have explored the potential benefits of utilizing solar energy as the primary power source for various applications. Maka and Alabid (2022) highlighted that solar energy is one of the most significant renewable and green energy sources available, and its continuous development makes it an attractive resource for generating electricity. They also emphasized the practicality of using solar panels, particularly for off-grid living, as it eliminates the need for expensive installations of electric utility poles and cabling.

In addition, Smith and Jones (2018) cited in the study of Smith et. al. (2021) focused specifically on the potential of solar energy to power smart trash bins, which offer a clean and sustainable energy source. The study explored the economic feasibility of integrating solar technology into smart trash bin operations and emphasized the environmental benefits, thus, these concepts are highly valued by the present researchers for the modification purposes of their product.

Also, Wang and Zhang (2019) highlighted the advancements in solar photovoltaic (PV) technology, emphasizing its role in harnessing clean and sustainable energy. The authors discussed the efficiency improvements and cost reductions in solar PV systems over the years, making solar energy an increasingly viable option for mainstream electricity generation.

Furthermore, Li et al. (2020) explored the environmental benefits of solar energy adoption, emphasizing its role in mitigating greenhouse gas emissions

and combating climate change. The study provided insights into the life cycle assessment of solar panels and their overall environmental impact, contributing valuable information for policymakers and stakeholders interested in promoting sustainable energy solutions. Overall, these studies highlight the potential benefits of utilizing solar energy as a primary power source, emphasizing its practicality, economic feasibility, and environmental sustainability.

These findings suggest the utilization of solar energy as its primary power source for the RE-TAPON machine. Maka and Alabid (2022) emphasized the practicality and attractiveness of solar energy for generating electricity, particularly for off-grid applications, which resonates with the RE-TAPON machine's capability to operate independently. Smith and Jones (2018) highlighted the environmental benefits of solar energy, including a reduction in carbon footprint, echoing the sustainable nature of the machine's power source. Additionally, Wang and Zhang (2019) discussed the advancements in solar PV technology, which underpin the efficiency and viability of the RE-TAPON's solar panel. Finally, Li et al. (2020) emphasized the environmental benefits and the need for supportive policies, aligning with the overall positive impact of the RE-TAPON machine's solar-powered design. The literature supports the practicality, economic feasibility, and environmental sustainability of the RE-TAPON machine's use of solar energy, reinforcing its role as an innovative and environmentally friendly solution.

1.4 Design

Figure 15. *RE-TAPON design*

The image showcases the RE-TAPON product, which has been designed for waste segregation and recycling purposes. It features a frame that houses various components, including a solar panel, on top to harness sunlight for power. The product also includes designated slots with sensors that detect recyclable materials. To facilitate movement, there is a DC motor powered by a 12V battery along with wheels for mobility. Additionally there is a plastic cover that allows visibility into the mechanisms to add more attraction to the students to see how this product works inside.

The design of the RE-TAPON product has been developed based on the recommendations provided by the panelists. According to panelist number 1 make the products front clear to capture students attention and allow them to observe its internal workings. Panelist number 2 suggested a horizontal design to promote ease of use and effective waste segregation. Additionally, they suggested considering a rectangular shape, widening it, and enlarging the hole for cans and bottles to accommodate larger sizes. Panelist number 3 recommended using light colors for additional features of the product. Lastly, panelist number 4 emphasized the importance of selecting a budget-friendly and eco-friendly material used in building a product.

The design not only showcases practicality but also highlights its environmental benefits, aligning with the insights from studies on solar energy and its role in sustainable development of Maka and Alabid, 2022. This integration of power sources resonates with the principles outlined in the

RE-TAPON project, where electrical conductivity and circuit principles are employed for waste segregation. The use of aluminum foil as a sensor detector mechanism complements the broader discourse on sensor-based technologies in waste management, drawing inspiration from the works of Cerezo et al. (2023).

In conclusion, the RE-TAPON product, crafted for waste segregation and recycling, encompasses a frame housing various components. These include a solar panel for harnessing sunlight, designated slots with sensors for recyclable materials, and a DC motor with wheels for mobility. The transparent plastic cover enhances visibility, engaging students in comprehending the internal workings of the product.

The design decisions, influenced by the suggestions of the panelists have significantly enhanced the product's effectiveness and appeal. Panelist number 1's recommendation of a clear front facilitates student attention and observation of internal mechanisms. Panelist number 2's input on a horizontal and rectangular design, coupled with larger slots for cans and bottles, ensures universal ease of use and effective waste segregation, aligning with the educational goals of the product. Panelist number 3's advice on incorporating light colors enhances the product's aesthetic features. Furthermore, the emphasis from panelist number 4 on selecting budget-friendly and eco-friendly materials underscores the product's commitment to sustainability.

The incorporation of solar power aligns with environmental considerations, in accordance with insights from studies on solar energy and sustainable development. This approach resonates with the principles of the

RE-TAPON project, where electrical conductivity and circuit principles contribute to efficient waste segregation. The use of aluminum foil as a sensor detection mechanism further aligns with contemporary discussions on sensor-based technologies in waste management.

2. Test and evaluation of product.

2.1. Functionality

Table 5. Summary of Functionality Results

EVALUATORS	MEAN	DESCRIPTION RATING
Evaluator 1	4.2	Very Good
Evaluator 2	4.5	Excellent
Evaluator 3	4.9	Excellent
Evaluator 4	4.5	Excellent
Evaluator 5	4.8	Excellent
Evaluator 6	4.8	Excellent
Overall Mean	**4.6**	**Excellent**

The table shows the evaluation on the performance of the developed prototype based on the functionality. The results of the evaluation, the overall mean is 4.6, and individual means per evaluator is 4.2, 4.5, 4.9, 4.5, 4.8, and 4.8, it can fairly be concluded that the evaluators are very satisfied with the outcome of the project. Results show that the highest mean is 4.9 and 4.2 appeared to be the lowest.

According to the study of Cerezo et. al. (2023) the detector used within the Electronic-Material Recovery Facility (E-MRF) utilizes aluminum foil-coated paper to detect the presence of materials such as paper, plastic bottles, or tin cans. When these materials come into contact with the aluminum foil-coated paper, an electrical circuit is completed, allowing electricity to flow and triggering the operation of components like a DC motor or battery. This setup showcases the detector's sensitivity and precision, as even a slight contact with the aluminum foil-coated paper can initiate the flow of electricity, enabling the E-MRF to efficiently identify and respond to the materials being sorted. By using this detector mechanism, the E-MRF automates the waste segregation process, enhancing efficiency and promoting recycling efforts.

Moreover, Smith and Jones (2018) cited in the study of Smith et. al. (2021) emphasize the substantial potential of solar energy in powering smart trash bins, presenting an environmentally friendly and sustainable energy source that aligns with the broader goals of green technology. To support this, Wang and Zhang (2019) have done a comprehensive study in which the advancements in solar photovoltaic (PV) technology emphasize its role in harnessing clean and sustainable energy.

The evaluation results of the developed prototype, as presented in the table, indicate a high level of satisfaction among evaluators, with an overall mean of 4.6. The success of the prototype can be attributed to the innovative detector mechanism inspired by Cerezo et al. (2023), utilizing aluminum foil-coated paper to detect various materials in the Electronic-Material Recovery Facility (E-MRF). This detector's sensitivity and precision, highlighted in the study, showcase the efficiency of the waste segregation process, as even minimal contact triggers the system's response. Additionally, the incorporation of solar energy, as advocated by Smith and Jones (2018) and supported by Wang and Zhang (2019), aligns the project with sustainable practices, further enhancing its appeal in the context of green technology.

Overall, the combination of an effective detection mechanism and environmentally friendly energy sources positions the prototype as a promising solution for efficient waste management.

2.2. Durability

Table 6. Summary of Durability Results

EVALUATORS	MEAN	DESCRIPTION RATING
Evaluator 1	3.8	Very Good
Evaluator 2	4.5	Excellent
Evaluator 3	4.5	Excellent
Evaluator 4	3.8	Very Good
Evaluator 5	4.8	Excellent
Evaluator 6	4.8	Excellent
Overall Mean	**4.4**	**Very Good**

The table shows the evaluation on the performance of the developed prototype based on durability. Based on the results of the evaluation the overall mean is 4.4, and the individual means per evaluator of 3.8, 4.5, 4.5, 3.8, 4.8 and 4.8, can fairly be concluded that the evaluators are very satisfied with the outcome of the project. Results show that the highest mean is 4.8 and 3.8 appeared to be the lowest.

According to Aquilah et. al. (2019), with proper maintenance and care, the Smart Trash Can is designed to be durable and long-lasting, providing a sustainable solution for waste management. In their study, the Smart Trash Can is made using strong iron material, ensuring durability and sturdiness in handling up to 15 kg of garbage. The prototype of the Smart Trash Can has been tested 30 times, showing that it can detect different types of waste and open containers automatically, indicating its reliability and durability in real-world scenarios.

The table evaluating the developed prototype based on durability reveals an overall mean of 4.4, with individual evaluator means ranging from 3.8 to 4.8. Despite the slight variation in individual scores, the overall mean suggests a generally high level of satisfaction among evaluators regarding the project's durability. The reference to Aquilah et al. (2019), discussing the durability of a Smart Trash Can made from strong iron material, provides valuable context. Although the RE-TAPON project employs wood as its frame, which may not be as sturdy as iron, the evaluators' high satisfaction levels suggest that the wood-based design is durable enough for their needs.

To conclude, it is important to acknowledge that material choice can impact durability, and the positive feedback indicates that the wood frame meets the expectations of the evaluators, showcasing a successful adaptation to the project's specific requirements.

2.3. Usefulness

Table 7. Summary of Usefulness Results

EVALUATORS	MEAN	DESCRIPTION RATING
Evaluator 1	4	Very Good
Evaluator 2	4.2	Very Good
Evaluator 3	4.9	Excellent
Evaluator 4	4.4	Very Good
Evaluator 5	4.9	Excellent
Evaluator 6	4.7	Excellent
Overall Mean	**4.5**	**Excellent**

The table shows the evaluation on the performance of the developed prototype based on usefulness. Based on the results of the evaluation, the overall

mean is 4.5, and the individual means per evaluator is 4, 4.2, 4.9, 4.4, 4.9 and 4.7, can fairly be concluded that the evaluators are very satisfied with the outcome of the project. Results show that the highest mean is 4.9 and 4 appeared to be the lowest.

In the study of Aquilah et. al. (2019), their Smart Trash Can prototype is equipped with sensors that can automatically detect different types of waste which allows users to easily identify the type of waste they are disposing of. Upon detecting, the Smart Trash Can opens the corresponding container automatically which enhances user convenience and promotes proper waste segregation. Their prototype also includes a hand sanitizer feature that users can utilize after disposing of garbage. This not only promotes hand hygiene but also helps in preventing the transmission of viruses like Covid-19.

The results of evaluation of the developed prototype based on usefulness indicates a high level of satisfaction among evaluators. The design feature of a transparent front view encourages user engagement by allowing them to see the waste being disposed of, enhancing the overall user experience. Additionally, the incorporation of a mechanism where improperly disposed waste comes out fosters a hands-on approach to waste management skills, promoting responsible disposal practices. Comparatively, the study by Aquilah et al. (2019) emphasizes the usefulness of their Smart Trash Can in waste segregation through automated detection and container opening. The inclusion of a hand sanitizer feature adds an extra layer of functionality, especially relevant in the context of promoting hygiene.

Project Evaluation Results

The project development study was analyzed by and evaluated by the chosen experts from the field of their expertise. Some are Electrical Engineers, Senior Cloud Engineer, and other experts whose jobs are related to the developed prototype.

In addition, the evaluation on the performance of the developed prototype was based on the functionality, durability and usefulness. Based on the results of the evaluation with an overall mean of 4.50 and individual means per factor of 4.62, 4.37, and 4.52 for functionality, durability and usefulness respectively, it can fairly be concluded that the experts are very satisfied with the outcome of the project. Results show that functionality got the highest mean of 4.62 while durability got 4.37 which appeared to be the lowest. Please refer to the table below for the details.

Table 8. Summary of Evaluation Results

CRITERIA	MEAN	DESCRIPTION RATING
FUNCTIONALITY	4.6	Excellent
DURABILITY	4.4	Very Good
USEFULNESS	4.5	Excellent
Overall Mean	**4.5**	**Excellent**

The experts gave the highest mean score to functionality because of the fact that the RE-TAPON has a derived purpose and is easy to use. Also, the quality of the system is reliable.

Summary of the evaluation on the criteria is presented below:

1. On functionality, the evaluators rated the prototype the highest, with a mean score of 4.6. It can be concluded that the prototype is easy to operate and is user-friendly.
2. Durability received a slightly lower mean score of 4.4. While still rated highly, there is room for improvement in making the prototype more sturdier and long-lasting according to evaluators feedback.
3. Evaluators found the prototype is highly useful, giving it a mean score of 4.5. This indicates that the system has productive range, accessible and has educational aspects on waste segregation.

Comments and suggestions of the evaluators towards RE-TAPON is presented below:

A. **Evaluator 1 -** "Safety wiring and provide schematic diagram, put switch, usage of proper insulation and mastery of the project."
B. **Evaluator 2 -** "Please make sure the safety wirings of your prototype. The use of aluminum foil is good but make sure to use a more durable type of material."
C. **Evaluator 3 -** "Add switch from battery to charger and use proper tape for safety."
D. **Evaluator 4 -** "Consider conductivity of other parts of the can (Bottom, Wrappings etc.) Paper bin should be more consistent, waste retrieval can be from the top (to remove need to move the bin. The segregator can be isolated from the trash. Weatherproofing can be improved."

The evaluators' comments provide valuable insights into areas where improvements can be made for the RE-TAPON project. Safety wiring emerges as a

recurring concern, suggesting the need for a comprehensive safety plan. Moreover a switch mechanism between the battery and charger is also recommended for added safety and control. Evaluators also highlight the importance of using durable materials beyond aluminum foil, ensuring longevity and reliability. Furthermore, conductivity issues within different parts of the can, such as the bottom and wrappings, need addressing to optimize performance. Simplifying waste retrieval by implementing a top access point is also suggested. Finally, weatherproofing enhancements would give the project's a better resilience to environmental conditions. Overall, by addressing these recommendations, the RE-TAPON project can improve safety, functionality, and durability, enhancing its effectiveness as a solution.

Chapter V

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and recommendations of the study.

Summary of Findings

The general objective of the study was to comprehensively evaluate the RE-TAPON project, focusing on its enhanced features and specifications in terms of materials used, sensor technology, power source, and design elements.

Specifically, this study sought answers to the following questions:

1. The objective was to explore the enhanced features and specifications of RE-TAPON in terms of:

    1.1 Materials used;

    1.2 Sensor Technology;

    1.3 Power source; and

    1.4 Design?

2. The aim was to test and evaluate the product RE-TAPON in terms of:

    2.1 Functionality

    2.2 Durability

    2.3 Usefulness

3. The goal was to propose a program to maximize the usability of RE-TAPON relative to waste segregation practices among students.

The study made use of an experimental design methodology, involving the construction of the RE-TAPON device using a variety of materials such as a 12V battery, solar panel, dynamo, foil, wires, wood, plastic cover, paint, wheels, cardboard, barbecue sticks, and plywood. The instrumentation of the RE-TAPON project involved the integration of innovative sensor technology alongside traditional mechanical components. Aluminum foil served as the primary sensor mechanism, strategically placed within the device to detect the presence of waste items. This sensor technology facilitated electrical conductivity when in contact with wires connected to a DC motor, enabling efficient waste segregation. Additionally, entrance points for cans and bottles were equipped with foam-filled drilled holes, ensuring proper electricity flow for effective operation. The power source, a combination of solar energy stored in a 12V motor battery, provided a reliable and sustainable energy solution for the device. Overall, the instrumentation of the RE-TAPON project demonstrated a thoughtful integration of sensor technology and mechanical components to achieve efficient waste segregation.

During the assessment stage, professionals evaluated the prototype according to its usefulness, durability, and functioning. A high degree of satisfaction among assessors was shown by the overall mean score of 4.50, with individual means for functionality, durability, and usefulness at 4.62, 4.37, and 4.52, respectively. The greatest mean score went to functionality, which highlighted the system's dependability, simplicity of use, and derived purpose. Although durability received a somewhat lower grade, evaluator commentary suggested that there was still an opportunity to increase sturdiness. Notably,

the prototype's utility scored highly overall, emphasizing its accessibility, productive range, and waste segregation teaching components.

However, assessments confirmed that the RE-TAPON project exhibited cutting-edge sensor technology, sustainable power consumption, and a well-rounded design, with excellent functionality, potential for durability enhancement, and significant use in trash segregation. In order to optimize the use of the RE-TAPON device, the results offered insightful information for future development and possible deployment initiatives.

Findings

The study yielded the following findings:

1. **Enhanced features and specifications of RE-TAPON**

The objective was to investigate the advanced features and specifications of the RE-TAPON project. This involved a comprehensive examination of the materials used, including a 12V battery, solar panel, dynamo, foil, wires, wood, plastic cover, paint, wheels, cardboard, barbecue sticks, and plywood. Additionally, the exploration included the sensor technology, particularly the use of aluminum foil as a primary sensor mechanism for waste detection, the power source which combined solar energy and a 12V motor battery, and the overall design elements that contributed to the device's functionality and efficiency.

2. **Evaluation of RE-TAPON**

The aim was to assess the RE-TAPON prototype in terms of its functionality, durability, and usefulness. Functionality was evaluated based on the system's dependability, simplicity of use, and effectiveness in waste segregation.

Durability was examined to determine the strength and long-term viability of the device, with a focus on identifying areas for potential improvement. Usefulness was measured by its accessibility, productive range, and educational components related to waste segregation.

3. **Implementation of RE-TAPON**

The goal was to develop a program to maximize the usability of the RE-TAPON device in waste segregation practices among students. This involved creating strategies and initiatives that leveraged the device's capabilities to educate and engage students in effective waste management. The program focused on promoting the practical application of the device in everyday waste segregation, thereby enhancing its impact and encouraging sustainable practices within educational environments.

Conclusion

Based on the findings, the following conclusions were drawn:

1. Expert evaluation of the prototype revealed high scores for functionality (4.62), emphasizing reliability and ease of use, while durability (4.37) received constructive feedback for potential improvement. The prototype's overall usefulness, with a score of 4.52, highlighted its accessibility, productive range, and educational aspects related to waste segregation.
2. With a solid foundation in construction and positive evaluations, the RE-TAPON project was well-positioned for potential program implementation aimed at maximizing its usability. Also, the device's commendable functionality, opportunities for durability enhancement,

and high usefulness made it a promising solution for broader impact in waste management initiatives.

Recommendation

In view of the findings, the following recommendations are offered:

1. Schools were recommended to adapt and implement the usage of RE-TAPON to teach the students proper segregation as it showed effects on waste management and students' discipline that would be beneficial to both students and the school.
2. The community was recommended to support this innovative project of the proponents by using it in public areas and different locales as it revealed the interest of the users in new technology that would help the community to make more researchers.
3. Families were recommended to adapt the usage of this project to have proper segregation practices.
4. The RE-TAPON was recommended in order to have a green community and to support the sustainable development goal.
5. Enhancement and modification were recommended in order to perfect the project.
6. Future researchers were recommended to do further research to have more functional, cost-efficient, sustainable, and convenient smart electronic trash bins.

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APPENDICES

APPENDIX 1. Evaluation Criteria for Prototype

RE- TAPON: RECYCLING ENGINE - TRASH AUTOMATON PROMOTES OPTIMAL RECYCLING AND NURTURES WASTE MANAGEMENT SKILLS

Name:_____ **Date:**_____

Instruction: Please evaluate the prototype by using the given and placing a checkmark under the corresponding numerical rating.

Numerical Rating	**Equivalent**	**Category of Evaluator**
5	Excellent	__ Mechanical Engineer
4	Very Good	
3	Good	
2	Fair	__ Others, please state _____
1	Poor	

INDICATORS	**1**	**2**	**3**	**4**	**5**
A. Functionality					
1. Working on derived purpose					
2. Easy to operate					
3. Comfort and convenience on the operator					
4. energy sustainability					
5. Portability					
6. Sensor accuracy					
7. Load capacity					
8. User safety features					
9. Adaptability to different sizes of waste					
10. Can differentiate wastes					

B. Durability					
1. Material's quality					
2.Program's quality					
3. Design's quality					
4. Output's quality					
5. Battery life					
6. Resilient to wear and tear					
7. Eco friendly					
8. weather resistance					
9. Ease of cleaning					
10. Resilience to Animal Interference					
C. Usefulness					
1. Productive range					
2. Fitted on its design					
3. Faster output than usual					
4. Lessen time and effort for the job					
5. Aesthetic appeal					
6. Educational features					

7. Accessibility					
8. Community Impact					
9. Ease of Waste Retrieval					
10. Public Engagement Features					

Summary:

a. Functionality __
b. Workability __
c. Durability __
d. Economy __
e. Usefulness __
f. Accuracy __

Evaluation Instrument Endorsed by:

_____

_____

Adviser

_____

SIGNATURE OVER PRINTED NAME OF EVALUATOR

APPENDIX 2. Creation of RE-TAPON

APPENDIX 3. Evaluation of RE-TAPON

APPENDIX 4. Research Defense

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Height :	62kg
Sex:	Male
Religion:	Roman catholic
Mother :	De Arao, Susana, Magbanlac
Father :	De la Cruz, Arcenes, Tolintino

EDUCATIONAL ATTAINMENT

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Sex:	Male
Religion:	Roman Catholic
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Father:	Daveryan Delizo

EDUCATIONAL ATTAINMENT

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Citizenship:	Filipino
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Height:	163cm
Weight:	53kg
Sex:	Female
Religion:	Roman Catholic
Mother:	Carmelita N. Lacida
Father:	Jory M. Lacida

EDUCATIONAL ATTAINMENT

Elementary: Taysan Central School
Junior High School: Mahanadiong National High School
Senior High school: Taysan Senior High School

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Weight:	48kg
Sex:	Female
Religion:	Roman Catholic
Mother:	Cecilia Magadia
Father:	Efipanio Magadia

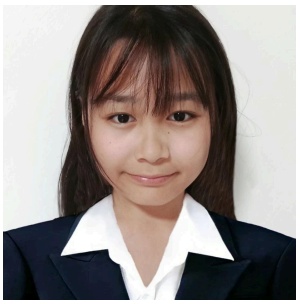
EDUCATIONAL ATTAINMENT

Elementary: Mabayabas Elementary School

Junior High School: Tilambo National High School

Senior High school: Taysan Senior High School

PEREZ, JAN FRANCINE MARALIT



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Mother:	Nhorielyn Perez
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Senior High school: Taysan Senior High School