POLYTECHNIC UNIVERSITY OF THE PHILIPPINES

SOLAR-POWERED REVERSE VENDING MACHINE: A REVERSE VENDING MACHINE FOR POLYETHYLENE TEREPHTHALATE (PET) BOTTLES

A Design Project Proposal
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Chapter 1

THE PROBLEM AND ITS SETTING

Introduction

Waste is being produced at an increasing rate all over the world, requiring the need for waste management. Waste management is the process of managing waste from the time it is generated until it is disposed of. Paper waste, glass and ceramics waste, plastic waste, and tins and metals are the most common types of waste generated worldwide. PET (Polyethylene Terephthalate) bottles, for example, take thousands of years to decompose.

The amount of plastic produced daily, and the use of such plastic materials harms the environment and poses a threat to the planet. Recycling is the process of converting waste into useful materials. It is fully implemented in Western countries with the government's support. Littering, on the other hand, is the norm in our country. Local governments encourage recycling, but only receive lukewarm responses. One local program is the placement of recycling bins in public places. As a result, we can see that the inconvenience and ineffectiveness of the recycling process discourages people from recycling. Another system used to increase recycling is to reward people who bring recyclable items. Hence, Reverse Vending Machine (RVM) is meant to encourage recycling habit by giving rewards to depositors for every recycled item in terms of reward points. Understanding the

advantages of Reverse Vending Machine, many countries have implemented these machines.

Plastic is ubiquitous; it is used for material packaging, transporting various items, and other practices such as surface protection. The world's population growth is causing an increase in solid waste, such as plastic waste. In 1950, plastic production was around 2 million tons, and by 2015, it had increased to 381 million tons. This is regarded as a significant shift in production that had a noticeable impact on the ecosystem (Ritchie, 2018).

Plastic can be found in massive quantities in the ocean. It is regarded as one of the most serious threats to marine life (PARKER, 2019). While only 8% of the plastic in the ocean breaks down into microplastic over time, more than 90% of it remains in the ocean. A 2015 estimate of the amount of plastic in the ocean revealed that approximately 150 million metric tons of plastic are polluting the ocean and are responsible for the deaths of 80 different species (Readfearn, 2020). The amount of plastic in the oceans is expected to reach 600 by 2040, million metric tons (PARKER, 2019)

The operation of reverse vending machine is like of an ATM. This is a machine with a bottle-accepting inlet. The bottle could be placed inside by the user. After

the bottle is inserted into the inlet, image processing is used to determine whether the bottle is suitable for recycling. If the bottle is accepted, the depositor will receive reward coupon. This project can be beneficial in a variety of ways railway stations, bus stops, Schools, and shopping malls are examples of such locations. The massive number of plastic bottles that are dumped on these if such machines are available, public spaces can be easily collected. Reverse Vending Machine (RVM) is an innovative concept introduced to aid in the collection recyclable materials and, as a result, to increase recycling activities.

The goal of this research is to find a suitable method for developing a machine dedicated to recycling plastic bottles, specifically those made of Polyethylene Terephthalate, or PET. Using this approach, we, the researchers, could try to provide recycling of plastic bottles in a more convenient way while also ensuring a system in which the consumer benefits from the action. As a starting point, we could consider the potential reconfiguration of our school's waste management as a social practice via the installation of Reverse Vending Machine.

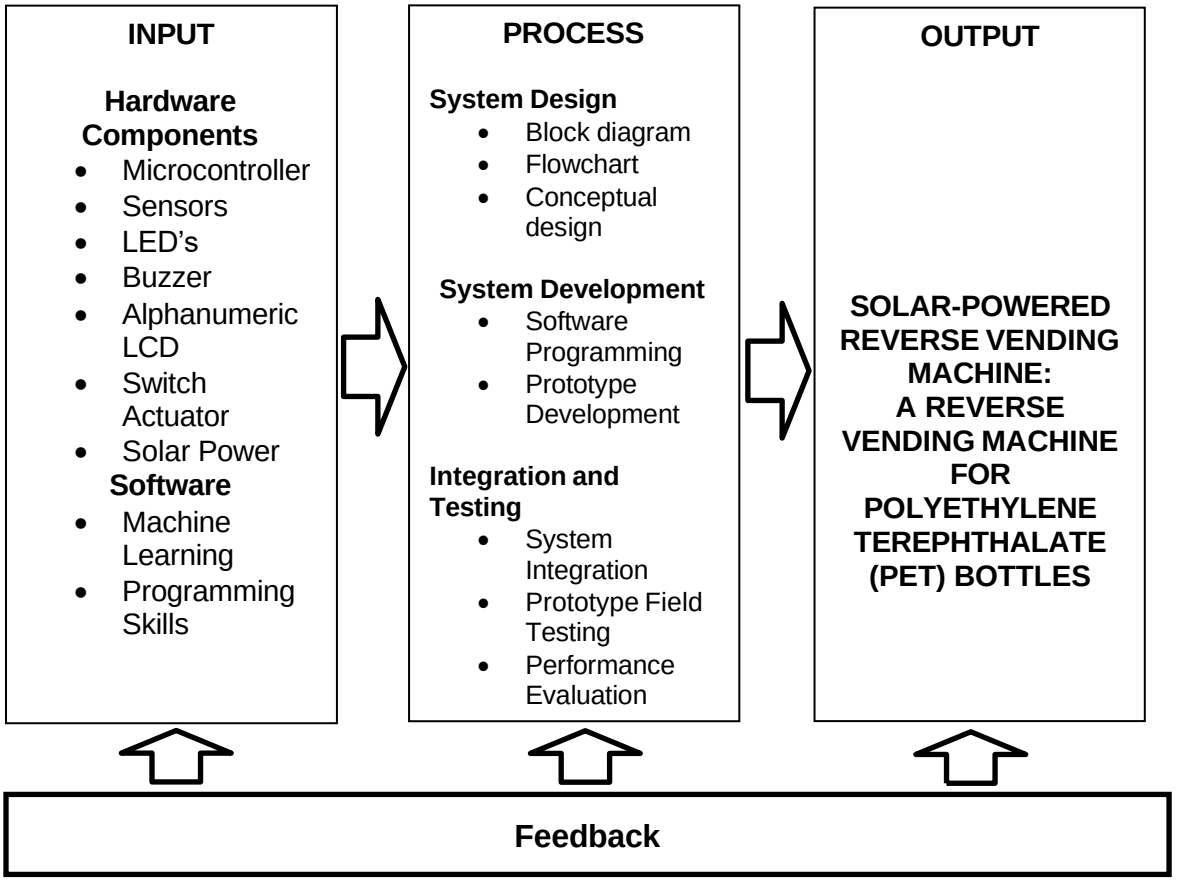
Theoretical Framework

Recycling and waste segregation are two of the most important waste management strategies. They should each have their own bin. The traditional method of segregating waste disposal at the dumpsite required more manpower and time to sort waste. The environmental effects of waste disposal sites have been studied, including the effects on water, soil, plants, and scavenging animals. Ryan and Galarpe (2017) examined the effects of waste disposal in the Philippines. Waste can be sorted in a variety of ways and forms. The findings of various studies found in the Literature Review of Automated Waste Segregation System using Machine Learning: A Comprehensive Analysis studied by Flores & Jr (n.d.), such as, Intelligent Waste Separator (IWS) that uses Machine Learning that can replace the traditional way of dealing with waste; The prototype automatically places garbage in altered basins and accepts inbound wastes by using To select and separate waste, a multimedia embedded processor, image processing specifically using the image recognition algorithm, and machine learning are used. It uses Infrared Sensors algorithm used by Azure Machine Learning System to notify the server if the bin is full and schedule for collection. Finally, an algorithm was not specified for the Automatic Waste Segregator and Monitoring System, except that it used an ultrasonic sensor and induction sorting. The proposed system will be able to monitor the solid waste collection process as well as manage the overall collection process.

Conceptual Framework

In this part of the research study, the input, process, and output of the proposed project will be shown. The input includes the software requirements, and hardware components requirements. The process includes system design, device creation and method used. Lastly, the output wherein the production manual of the development of “Solar-Powered Reverse Vending Machine: A Reverse Vending Machine for Polyethylene Terephthalate (PET) bottles”. The conceptual framework will serve as the basic flow chart of the system wherein, the readers can easily understand how the entire system work.

Figure 1. Conceptual Framework Paradigm



The machine is built with hardware components. It is a necessary component of the machine. The materials are the objects that we use to put the pieces together. Each of the hardware components inside the RVM requires materials to be attached. System design is concerned with constructing how the machine will work. Device creation necessitates technical skills such as programming knowledge, particularly for the Arduino Uno, machine learning knowledge for waste management, and microcontroller skills for the machine's circuit. We could build our device using all the variables listed above. Following the creation of the machine, we would obtain feedback from people who had used it; these feedbacks would be applied to the variables that we used to create our machine; changes would be required for the machine to be better and more user-friendly.

Statement of the Problem

The purpose of this research/project, these relate in general to waste management and recycling the plastic bottles in the environment. The littering of plastic wastes in the environment and less willingness to recycle the plastic presents a continuing problem to the environment and to all living beings.

By being able to access easy ways to recycle containers, as well as being able to collect a reward coupon upon returning their plastic bottles, people are much more likely to get involved with recycling. This means that more people are

contributing and doing their part, leading to fewer bottles and containers that can be recycled being thrown away.

Specifically, this study seeks solutions to the following problems:

1. What are the stages undertaken in the development of Solar-Powered Reverse Vending machines?
2. What are the evaluation of garbage collectors, students, and another individual in the prototype to be developed in terms of;?

   2.1 Performance Efficiency

   2.2 Usability

   2.3 Functional Suitability

   2.4 Maintainability?

3. What is the difference between the evaluation of garbage collectors, students, and other individuals in the aforementioned variables?
4. How effective is the proposed system in alleviating waste management issues compared to the conventional waste management system?
5. What are the issues encountered by the garbage collector, students, and other individuals, using the proposed system?
6. What informative presentation may the researchers develop to inform the public regarding of the Solar-Powered Reverse Vending Machine?

Hypothesis

Will the Solar-Powered Reverse Vending Machine for Polyethylene Terephthalate will change the behavior of the collection of PET bottles compare to separate bins by types of recyclable wastes and non-separate bins?

Scope and Limitations of the Study

The study sought to determine whether the development of a Reverse Vending Machine for Polyethylene Terephthalate Plastic Bottles can help to alleviate waste disposal issues and thus promote recycling among Polytechnic University of the Philippines-Parañaque City Campus students. We researchers also believe that this study will benefit the environment and future researchers. The following is the scope of work to be done in this research. The machine will be confined to accepting PET plastic bottles only with the transparency of 88.8%-100%, and weight: 8.9grams – 24.5grams. The machine has a bin that can hold plastic bottles. The machine will be able to vend off e-vouchers appropriate to the number of plastic bottles inserted in the machine. The machine will be able to determine: When it reaches the maximum number of plastic bottles inserted.

This will be conducted at the Polytechnic University of the Philippines – Parañaque City Campus. The system will be completed on 2nd Semester of Academic Year 2021-2022

Significance of the Study

The study sought to determine whether the development of a Reverse Vending Machine for Polyethylene Terephthalate Plastic Bottles can help to alleviate waste disposal issues and thus promote recycling among Polytechnic University of the Philippines-Parañaque City Campus students. We researchers also believe that this study will benefit the environment and future researchers.

With improper waste disposal, such as not segregating biodegradable from non-biodegradable waste in our country, this project could reinforce the recycling campaign. In the long run, people will be able to continue the practice of recycling and even improve its process, thereby protecting the environment and providing us with a better place to live. This section of the document presents the list of beneficiaries of the group of persons who may maybe benefit from this project.

Computer Engineering Students. this will strengthen their learnings and give them more ideas to improve their abilities in promoting alternative automation of existing principles.

Department of Science and Technology. As a premiere science and technology body in the Philippines charged with the twin mandate of providing central direction, leadership, and coordination of all scientific and technological activities, and of formulating policies, programs, and projects to support national development, the Department of Science and Technology will benefit from this study because this will be a good innovation for the manual segregation of wastes.

Department of Environment and Natural Resources. One of the departments that I responsible for making environment clean and green. In that case our project would be beneficial for the said department.

PUP-Parañaque Campus. this study helps the school promote awareness about the importance of recycling and proper waste disposal. At the same time rewarding the students through vending rewards for an equivalent amount of every bottle inserted.

The Environment. It keeps litter and waste out of the groundwater, oceans, and streets. It can inspire people to collect plastic waste and instead of throwing it, they can deposit it on the reverse vending machine and get a reward.

The National Solid Waste Management Commission (NSWMC). The agency that is responsible for implementing the republic act no.9003 otherwise known as the Ecological Solid Waste Management Act of 2000, provides the necessary

policy framework, institutional mechanism and mandate to the logical government unites (LGUs) to achieve 25% waste reduction through establishing an integrated solid waste management plan based on 3Rs (Reduce, Reuse, and Recycling)

Definition of Terms

This section discusses the technical terms used in this research. The following terminologies are conceptually and operationally defined for better understanding of the readers.

Functionality suitability. Function suitability is a quality factor describes the extent to which a software product or system provides functions that satisfy the stated and implied needs of stakeholders when used under specified conditions. This quality factor has been divided into three (3) lower factors including functional completeness, functional correctness and functional appropriateness (Peters & Aggrey, 2020). In this research, since image processing has a wide range of applications, there must be a criterion for quality, such as functional appropriateness, to help evaluate this function.

Machine Learning. A built-in algorithm which can perform a certain task.

Maintainability. Maintainability is the ability of software products or systems to be modified, corrected, or adapted to current changes in the environment describes its maintainability feature. Five (5) lower factors including modularity, reusability, analyzability, modifiability, and testability were associated to maintainability (Peters & Aggrey, 2020).

Microcontroller. A single chip that is designed to perform the specific task of an embedded system.

Performance efficiency. Performance efficiency is a factor that describes the ability of a software product or system in managing the given number of resources to provide and maximize performance. This quality factor has also been decomposed into three (3) lower factors including time behavior, resource utilization and capacity (Peters & Aggrey, 2020).

Sensor. Sensors are devices that detect changes in the environment and respond to some output on the other system.

polyester family, bio-degradable and semi-crystalline.

Solar Power. Solar power is the use of the sun's energy either directly as a thermal energy (heat) or using photovoltaic cells in solar panels and transparent photovoltaic glass to generate electricity.

Usability. Usability is a factor describes the extent to which software or system product can be used to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. The usability factor has set of lower factors which include appropriateness recognizability, learnability, operability, user error protection, user interface aesthetics and accessibility (Peters & Aggrey, 2020

Chapter 2

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter will discuss related literatures and studies that are like the current study, allowing the researchers to understand the proposed research study. The discussion is presented using a thematic approach.

Software Development

Aleksandr I. Tur, Andrey N. Kokoulin, and Aleksandr A. "Convolutional Neural Networks Application in Plastic Waste Recognition and Sorting." Kokoulin describes their findings in an IoT and Convolutional Neural Networks application in a reverse vending machine in his paper. This machine is built with IoT controllers and tiny single-board computers with limited memory and computational power. These controllers could identify various types of waste using cameras, as well as sorting and preprocessing. This paper demonstrates the use of CNN on IoT for reverse vending machines.

Edgar Scavino proposed a machine vision experiment that was used to identify and extract recyclable plastic bottles from a conveyor belt. Color images of the bottles were captured using a Webcam, and identification was performed using our own software based on the shape and dimensions of the object images. The goal is to teach a computer to behave similarly to humans: to learn what an image contains. The main technology behind driverless cars is image recognition, which

allows them to detect a stop sign or distinguish a pedestrian from a lamppost. It is also useful in a wide range of applications, including disease detection in bio imaging, industrial inspection, and robotic vision.

"Development of Bottle Recycling Machine Using Machine Learning Algorithm," Pravin Dhulekar, S. T. Gandhe, and Ulhas P. Mahajan, 2018 International Conference on Advances in Communication and Information Technology. Dhulekar's paper used a machine learning algorithm developed on the Python platform to classify and collect used bottles. The system is made up of a Raspberry-PI connected to a camera and an audio-visual interactive system. The reward is given in the form of a printed coupon generated by a thermal receipt printer. The machine is designed to accept plastic bottles and credit them as points, which are then redeemed can be used to purchase goods. The proposed BRM design allows for bottle identification and efficient recycling at a low cost.

Hardware Development

One of the self-service technologies is reverse vending technology. Self-service technologies (SSTs) are technological interfaces that allow customers to produce a service without the involvement of a direct service employee. ATMs, vending machines, interactive kiosks, automated hotel checkouts, and so on are examples. Meuter et al. (2000) classified SST into two dimensions: 1) interface (telephone/interactive voice response; online/internet; interactive kiosks; video/CD) and 2) purpose (customer service; transactions; self-help). The current

spread of new self-service technology (SST) driven primarily by technological advancements suggests the need to evaluate the extent to which consumers are willing to use new technology and the need to address consumer acceptance to ensure successful SST deployment Previous studies have concluded that the adoption of SST is generally influenced by technological characteristics as well as individual differences. Several studies on the acceptance of self-service technologies (SSTs) have already been conducted; however, no studies on the acceptance of reversed vending machines have been conducted. As a result, the related literature and research on SSTs was used as one of the references in this study. Several studies have proposed theoretical models to better understand and explain people's attitudes and behaviors toward new technology.

Maofic Farhan Karin Khandaker Sharif Noor Hasan U. "Hardware Based Design and Implementation of a Bottle Recycling Machine Using FPGA," Zaman, IEEE Conference on Systems, Process, and Control, 2016. (ICSPC 2016), Melaka, Malaysia, December 16–18, 2016. Farhan proposed the design of a Smart Bottle Recycle Machine (SBRM) in Maofic. It is built on a Field Programmable Gate Array and employs an ultrasonic range sensor. The detector was used to count the bottles and differentiate between them. PGA was chosen because hardware-based implementation on an FPGA is typically much faster than software-based implementation on a microcontroller.

Effectiveness/Efficiency of the System

The most recent type of mechanical recycling machine is the reverse vending machine, which shreds plastic bottles into flakes that can be reused in the production of fibers, clothing, and ropes. In a typical mechanical recycling process, the machine first shreds the plastic, then separates any contaminants (paper, dust), separates different types of plastic, and then mills it. The plastic is then cleaned, washed, and formed into strands, from which single polymer plastics are formed. The plastic is finally water-cooled and sold as a finished product. As a result, recycling is a better option than plastic waste disposal (Al-Salem,Lettieri & Baeyens, 2009).

The RVM encourages the community to dispose the waste approriately (Tomari, Kadir & Jabbar, 2017). While the products which help recycling are available, they are not effectively utilized by the citizens. The reasons for limited utilization are varied. The comprehensive model of recycling behavior (Valle et.al. 2005) shows that the variables which influence recycling behavior include attitude towards recycling, personal norms, specific knowledge about the available recycling options, perceived convenience, governmental attitudes, and personal values play an important role.

The authors have mentioned that Theory of Planned Behavior (TOPB) is a good starting point to understand the factors influencing the recycling behavior. In this theory we see that the communication is not a significantly influencing behavior

whereas it is intuitive that only when the different methods of recycling is communicated to the masses it creates awareness and only then it might have a higher probability of adoption. The recycling rate study (Sidique et al. 2010) provides evidence of this.

According to the study, the cost of waste disposal, government regulations and ordinances that make recycling mandatory, curbside recycling services, and drop off centers all help to improve the rate in terms of recycling the author emphasizes that educating the public to raise awareness has also had an impact on the rate of recycling. This study demonstrates that convenience in terms of curbside services and education to raise awareness are factors that influence the adoption of recycling methods, as confirmed by Domina's research. & Koch.

According to Momoh and Oladebeye's research, awareness is an important predictor of recycling behavior. They investigated the effect of convenience on recycling frequency as a predictor of recycling behavior. Access, shopping habits, income, family size, and age are the variables investigated. The study found that the variables considered were significant predictors of recycling behavior, regardless of how recycling activities were defined (Domina. & Koch, 2002). While the cost of waste disposal must be affordable to improve outcomes, providing incentives will also influence citizens' recycling behavior.

According to the literature, citizens' willingness to participate can be measured by the degree of cooperation and commitment to a household solid waste program

(Momoh & Oladebeye, 2010). It was discovered that one variable that cannot always be explained by socio-demographic and socioeconomic variables is willingness to recycle. As a result, we believe that convenience, incentives, willingness, involvement, and awareness could be studied further to better understand its interdependence.

Issues and Challenges using the System

A case study about “Economic implications of the ban on single-use plastics in the Caribbean” showed that supermarkets in Trinidad and Tobago are considered as a high consumer of plastic, especially plastic bags (Phillips, 2020). The study showed that the average number of white medium plastic bags used in the supermarkets per month is the highest with 15000 plastic-bag compared to a bakery, food manufacturer, and restaurants. The solution that they have implemented is about banning single-use plastic. In this way they are forcing all related sectors to move towards a clean, recyclable, and eco-friendly replacement. Paper bags were the replacement of plastic bags, they affected the total monthly operating cost in supermarkets by 532 011 TTD. Their solution was good for the environment, but from economic perspective it increases the cost by 9.6% to 16.9% across different business sectors including supermarkets (Phillips, 2020).

According to a study published by WPI about “Reduce, Reuse, and Replace: A study on solutions to plastic wastes”, plastic is responsible for 11.7% of the municipal solid waste (MSW) in the United States as shown in figure 2 (Li, 2009).

Moreover, the study mentioned that although the percentage of the plastic in MSW is not that high, but it has the lowest rate of recycling and recovery among other materials such as glass and metals. The study suggested many solutions for over plastic production, one of the solutions was chemical decomposing. They suggest developing a technology that helps in converting plastic into non-harmful particles as this will be a good solution on the economic and environmental level. The study gives many reasons behind this solution, such as the cheap production of the plastic, the easy transportation of the plastic as it occupies less space compared to other materials like fabric and paper. In addition, it pays attention to the workers in plastic industries, many will lose their job if plastic production has stopped.

According to the article “Recycling Waste Plastic Bags as a Replacement for Cement in Production of Building Bricks and Concrete Blocks”, the special characteristics of plastic gave it an advantage over other materials as its waterproof, low cost, and suitable for carrying different objects. These characteristics makes plastics hard to be replaced, therefore the study focused on finding different ways to recycle this plastic instead of replacing it with another material. A suggested solution was to use plastic in constructions, this will be done through producing concrete blocks, and bricks using sand and waste plastics. They found that the amount of waste plastics used in making concrete blocks and plastic bricks, is affecting their thermal conductivity. By increasing the number of plastic wastes, the thermal conductivity decreases (Hassanien, 2020).

Intervention Training Programs

San Juan signs environmental MOAs, launches PH's first reverse vending machine. On Tuesday, March 22, the San Juan City municipal government teamed with various environmental protection organizations to improve its environmental protection initiatives as it progresses towards a greener city. Mayor Francis Zamora presided over the signing of multiple memorandums of understanding (MOA) with Greenpeace Country Director Lea Guerrero, Plastic Credit Exchange Founder and Chairman Nanette Medved, and Eastwest Builders Inc. CEO Arthur Lee. Zamora explained that to encourage people to recycle, they will be given incentives in the form of redemption coupons. There will be redemption times set aside for those who receive coupons after recycling their bottles and cans through the machine. Rewards will initially be claimed through redemption booths, but the city government is already in the process of partnering with various malls to convert coupons into points in their reward cards. "We hope that these recycling and single-use plastic refusal initiatives gain traction and encourage San Juaneos to reduce their carbon footprint." If it is successful, we will be able to deploy more RVMs in high-traffic areas of the city and install more Aling Tindera stations throughout the city," Zamora explained.

In 1971, the owner of one of Oslo's largest supermarkets approached Petter, who was then a salesperson for supermarket labeling and pricing systems, with a dilemma. Supermarkets in Norway are required by law to refund consumers for empty bottles, but in the early 1970s, they were having difficulty dealing with the

high volume of returned bottles. To keep supermarkets from drowning in empty bottles, the owner needs some sort of automated processing device. With no such technology available at the time, Petter advised the owner to contact his brother Tore, who was working on the world's first automatic navigation systems at the time.

V. K. S. Pavan, V. S. S. S. Akhil, P. N. S. Kumar and P. B. K, "Implementation of Reverse Vending Machine Technique for Dry Waste and E-Waste," 2021 5th International Conference on Electronics, Materials Engineering & Nanotechnology (IEMENTech), 2021, pp. 1-7, doi: 10.1109/IEMENTech53263.2021.9614824.

Human activities always produce garbage. This wasn't a big deal when the human population was small, but it became a major issue with urbanization and the subsequent expansion of the massive metropolis. Poor waste management resulted in contamination of water, soil, air, and environment, as well as a negative impact on public health. As people' lifestyles changed, new waste products evolved, increasing the number of chemical compounds contained in diverse waste streams substantially. Exposure to these compounds has a long-term health effect, especially when the concentrations are very low and there are multiple exposure channels such as air, food, soil, water, and so on. Increasing recycling rates can significantly lessen the long-term effects of waste generation. Recycling not only saves energy, but it also reduces greenhouse gas emissions, which aids in the fight against temperature and climate change. Nowadays, recycling requires people to transport their waste in bulk to the recycling center, which can be

inconvenient and discourage people from recycling. To address this issue, a prototype model for a reverse vending machine is offered, which employs the waste-to-wealth principle.

Solid waste management issues

Solid waste management is not only a major issue in the Philippines, but it is also regarded as a global issue. In the Philippines, Metro Manila has 12 million more people than other cities due to waste management issues (Ballaran et al., 2019). The Philippines' projected annual waste of 18.05 million tons by 2020 is expected to rise to 77,776 tons daily by 2050. (Enp.Tinio, 2021). According to Abarca-Guerrero et al. (2015), because of the continuous increase in waste, solid waste management poses a challenge in city government in developing countries. As a result, the cost of solid waste management increased, putting a strain on the municipal budget.

In the Philippines, the Republic Act (RA) 9003-Ecological Solid Waste Management (ESWM) Act of 2000 mandates and serves as a framework for solid waste management (Miguel, n.d.). The issue was a lack of implementation in some local governments. Due to a lack of technical equipment, financial resources, government action, and societal awareness, it resulted in unregulated landfills and dumpsites. Monitoring dumpsites and landfill operations was another issue.

Dumped waste can cause hazardous chemical leaks that endanger the environment and pose health risks to society. The government's national mandate can be fulfilled if local governments commit to its objectives, develop effective local strategies, form partnerships with other stakeholders, build capacity, provide adequate financing and incentives, and closely monitor and evaluate performance (Gamaralalage, 2013).

Reverse Vending Machine

One of the technologies being developed is reverse vending technology used by other countries, particularly in the United States and Europe can be regarded as an efficient technology for data collection PET bottles should be recycled. This technology makes use of a machine. also known as a Reverse Vending Machine (RVM). The inverse empty plastic bottle containers are accepted by vending machines and rewards in the form of a cash coupon or a point card. Reverse vending technology was created to improve the recovery and disposal of recycled products. Tomra Systems ASA patented the idea under the brief description of a machine that "receives, handles, sorts, and stores." Items or objects that are returnable the basic operations begin with the consumer/waste generator inserting the empty bottle into the receiving aperture; the horizontal in-feed system allows the user to insert containers one at a time.

Related Literature on Technology Acceptance and Adoption

Reverse vending technology is considered as one of the self-service technologies. Self-service technologies (SSTs) are technological interfaces that enable customers to produce a service independent of direct service employee involvement. Examples are automated teller machines (ATMs), vending machines, interactive kiosks, automated hotel checkouts, etc. Meuter et al. (2000) introduced a classification of SST into two dimensions: 1) interface (telephone/interactive voice response; online/internet; interactive kiosks; video/CD) and 2) purpose (customer service; transactions; self-help). The propagation at the present time of new self-service technology (SST) driven primarily by technological advancements suggests a necessity to assess the extent to which consumers are willing to actually use new technology and the need to address consumer acceptance to ensure successful deployment of SSTs. Previous research done conclude that the adoption of SST is generally driven by technology characteristics and individual differences [8]. Several studies have already been conducted on the acceptance of self-service technologies (SSTs), however, no studies have been conducted specifically on the acceptance of reversed vending machines. Hence, the related literature and research pertaining to SSTs have been used as one of the references in this study. Several studies have proposed theoretical models to better understand and explain individual attitudes and behaviors toward new technology.

Synthesis of the Reviewed Literature and Studies

The above-mentioned studies will aid in the development of a Solar-Powered Reverse Vending Machine.

Plastic bottles find common use in a wide range of applications in our daily lives. As a result, production and use of plastic bottles has increased remarkably over the years. The high demand of plastic bottles, especially in the water and soft drink industry, has brought with it severe environmental problems due to careless disposal of these bottles. Recycling and re-manufacturing, in essence, would allow the production of new products with lower material inputs than would otherwise be required. Recycling can thus reduce the amount of energy and materials used to create new goods, resulting in less waste and pollution. The energy-saving a complex system of machines and new manufacturing practices were required for the plastic recycling process.

The study was carried out to confirm the interpretations of the literature and to determine whether the variables play a role in Reverse Vending Machine (RVM) adoption. The field study was divided into two phases: testing the functionality and efficiency of Reverse Vending Machine (RVM) and observing citizens attitudes toward Reverse Vending Machine. Reverse Vending Machine adoption suffers from a lack of awareness and participation. Convenience, Incentives, Involvement,

Willingness, and Awareness are the factors examined. According to the findings, citizens willingness to adopt new recycling methods is most strongly influenced by their involvement in recycling methods and environmental concerns. These provide the researchers with the inspiration they require to produce the desired results.

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