WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE

A Thesis
Presented to the Faculty of
Information and Communications Technology Program
STI College San Jose

In Partial Fulfilment
of the Requirements for the Degree
Bachelor of Science in Computer Science

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November 7, 2024

ENDORSEMENT FORM FOR ORAL DEFENSE

TITLE OF RESEARCH: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE

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In Partial Fulfilment of the Requirements
for the degree Bachelor of Science in Computer Science
has been examined and is recommended for Oral Defense.

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November 7, 2024

APPROVAL SHEET

This thesis titled **WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE** , prepared and submitted by **John Paul H. Clarito; Laurence Christopher C. Dugay; ; Franz John Chloe T. Navalta;**; and **Christian Paul L. Valdez,** in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science, has been examined and is recommended for acceptance and approval.

Joel M. Pascua
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Accepted and approved by the Thesis Review Panel
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ABSTRACT

Title of research: **WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE**

Researchers: **John Paul H. Clarito**
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Degree: **Bachelor of Science in Computer Science**

Date of Completion: **August 2025**

Keywords: **Machine Learning, Proper Waste Segregation, Separate Wet and dry plastics**

Through our research, the introduction focuses on waste management. The issue is the increasing amount of solid waste due to the growing population. The LGU has declared the implementation of programs, including the Solid Waste Management program or the Ecological Solid Waste Management Act of 2000. Ms. Glenda Garcia has observed the problem of garbage disposal over the years. Despite labeling the garbage, many individuals failed to properly dispose of the trash. Ms. Garcia noticed that dry and wet plastics are often mixed together in the trash cans. She implemented a program from CENRO called Environmental Education for individuals. This program aims to help people understand the waste management situation. To address the current state of technology, Ms. Garcia focuses on the Palit Basura Program, which emphasizes separating dry and wet plastics. As the researchers, the objective of the study is to enhance waste segregation precision, provide real-time bin monitoring status, and minimize overflow incidents. The study examines the actual components of the machine, with the Arduino microcontroller serving as the central component for powering segregation. The GSM module is included to enhance the waste segregation machine with real-time connectivity for alert purposes. The conveyor pad, idle roller, and motor support the sorting process for wet and dry plastics.

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INTRODUCTION

According to Leton and Omotosho (2004), solid waste is defined as a non-liquid and non-gaseous product of human activities regarded as being useless and could take the form of refuse garbage and sludge. Waste generation and disposal is one environmental problem that has been of great concern to local inhabitants, local, state, and federal governments, as well as the world in general (Ishoka, 2008). The continuous growth of the population, the rising generation rate of every Filipino, and the characteristics of solid waste generated create a managerial problem for both the national and the local government authorities (Dungo, C. 2001).

Philippines is beset with challenges accompanying the increasing population that exacerbates the problem of solid waste. Under the Local Government Code of the Philippines 1991 (Republic Act 9003 [RA 9003]), it is expected that Local Government Units (LGUs) perform their role in implementing programs mandated by the national government, including the Solid Waste Management (SWM) program. RA 9003 or the Ecological Solid Waste Management Act 2000 was enacted to address the worsening garbage problem, along with its environmental and health impacts (Miriam Ramirez Nguyen, 2020).

One of the most urgent issues facing the globe today is waste management, and sensors are now being used to expedite the procedure and save time and money. (Owais Ali, 2015).

A microcontroller is a stripped-down processor that is equipped with memory, timers, parallel I/O pins, and other on-chip peripherals. The driving element behind all this is cost. Integrating all elements on one chip saves space and leads to both lower manufacturing costs and shorter development times. This saves both time and money, which are key factors in embedded systems. (Gunther Gridling, 2007).

Microcontrollers are commonly used in agricultural areas for various applications such as automated irrigation systems, soil moisture monitoring, temperature and humidity control,

plant health monitoring, etc. On the other hand, using Arduino in mathematics teaching can be an innovative and engaging way to enhance students' understanding and practical application of mathematical concepts. (Jaime Cuauhtémoc Negrete, 2020).

The city of San Jose's CENRO office, which stands for "City Environment and Natural Resources Office," is situated on the second floor of the building directly in front of the municipal hall. The CENRO was established in 2005 as part of the Department of Environment and Natural Resources (DENR) to support its mandate of promoting sustainable development in the Philippines. The CENRO ensures that activities related to the environment and natural resources are carried out properly by monitoring land use, resolving environmental conflicts between communities and other stakeholders, managing disaster response, and providing technical assistance to local communities. Its main purpose is to ensure that people living in rural areas can access resources for their livelihoods without compromising environmental sustainability. (**O**nlineabriviation,2023).

Background of the problem

Ms. Glenda Garcia, a pollution control officer, has expressed her concern about the improper disposal of garbage in public places. Despite the labeling of every garbage bin, she has observed that individuals often disregard it and throw their trash improperly. She believes that many people lack the discipline to correctly use the designated bins for trash disposal. This is a worrying trend, as it can have serious consequences for the environment and public health.

According to Ms. Garcia, 50% of overall garbage is made up of plastic. This includes various types of dry and wet plastics that are often mixed, such as plastic bags, wrappers, cups, and bottles. However, not all types of plastic are created equal in terms of their recyclability. Dry plastic waste, such as plastic bags and packaging, can often be recycled and made into new products, while wet plastic waste, such as discarded drink bottles that still contain liquids, may be considered residual waste and can be more challenging to recycle. The mixing of different types of plastic waste can make it difficult to properly dispose of and recycle, which poses a significant challenge in the efforts to reduce plastic waste and its impact on the environment. This makes it also difficult for waste management personnel to sort and process the waste efficiently. Moreover, waste management personnel must physically visit all the waste collection points without knowing the bin's status. This leads to two potential situations: either there is no waste requiring collection or the bin has reached its capacity and is overflowing. Both situations can lead to further environmental and health hazards. Garcia further added that despite the efforts to address the issue of poor waste management practices in public places, such as City Social Circle (Keg-Keg) and San Jose City Public Market, by encouraging and providing guidelines for sanitation in public places, little is known about promoting environmental sanitation through environmental education. It is essential to educate people about the importance of proper waste management to maintain a clean and healthy environment. Environmental education can help individuals understand the impact of their actions on the environment and encourage them to adopt sustainable waste management practices.

Overview of the current state of the technology

Ms. Garcia's statement highlights the "Palit-Basura" program, which is being carried out by the City Environment and Natural Resources Office (CENRO), is an initiative that aims to address the growing problem of plastic waste. The program mainly focuses on dry plastics, such as snack and candy wrappers, which are often difficult to manage due to their low density and non-biodegradable properties. These types of plastics often end up in landfills or pollute the environment, causing harm to wildlife and ecosystems.

Through this incentivized approach to responsible waste disposal, the program promotes environmental awareness and encourages citizens to be more conscious of their waste management practices. By collecting and exchanging their dry plastics, participants contribute to reducing plastic waste and promoting a cleaner and more sustainable environment. Moreover, the exchange of practical items like soap or laundry detergent powder incentivizes individuals to continue to participate in the program, thus further promoting responsible waste management and reuse of plastics in a creative and sustainable manner.

In contrast to dry plastics, wet waste materials that are deemed non-recyclable or non-exchangeable undergo different processes. The Plastic Pulverizer, a machine designed to crush and pulverize plastic waste, is utilized for this purpose. This process aids in reducing the volume of plastic waste and preparing it for potential recycling or disposal.

The strategic placement of the plastic pulverizer in the solid waste department office at the San Jose City Public Market demonstrates the importance of having waste processing infrastructure located in key areas within the city. This approach ensures that waste management is efficient and effective, reducing the environmental impact of plastic waste in the community. After the plastics have been pulverized, they are transported to the Metro Clark Waste Management Corporation.

In addition to the initial waste management system, Metro Clark Waste Management Corporation (MCWM) operates the country's first and most sophisticated engineered sanitary landfill. This landfill technology is a significant step towards addressing the waste management issues in the Philippines, where the expanding population and rising urbanization fuel the impending garbage crisis.

However, despite the initial waste management system's efforts, the researchers found out that dry plastic and wet plastic waste are being mixed in the garbage bin, particularly in public places. This issue is prevalent due to the lack of awareness and education about

proper waste segregation, highlighting the need for better education and awareness campaigns to promote proper waste segregation practices.

Figure I: Shows the Bio-degradable bin.

Figure II: Shows an overflowing bin

Figure III: shows the dry plastic waste and wet plastic waste is mix in the bin.

Objectives of the study

The focus of this thesis is the development of the "Sustaining," an inventive solution aimed at separating dry and wet plastic waste items, while promoting recycling and minimizing environmental impact in City Social Circle (Keg-Keg).

The following specific objectives has been formulated after developing the hardware:

1. Enhanced Waste Segregation Precision:

Enhance the segregation of dry and wet plastic waste, with the help of soil moisture sensor detection, achieving a more effective differentiation between the two.

2. Real-Time Bin Status Monitoring Impact:

   Provide timely information with the use of GSM Shield indicating whether a bin required collection or had reached its capacity.

3. Minimized Overflow Incidents Outcome:

   Contribute to help enhancing cleanliness to City Social Circle (Keg-Keg), thereby to lessen the risk of overflowing.

Scope and limitations of the study

Scope

“Wasebin” focuses on the segregation of dry and wet plastic waste. The scope includes the integration of an Arduino microcontroller with a GSM module for alert purposes, providing a technological solution for waste segregation and monitoring. The research focuses on communal spaces, particularly the urban social hub known as City Social Circle (Keg-Keg), aiming to assess the applicability and effectiveness of the "Wasebin"

technology in diverse environmental settings.

Actual Components

Arduino Microcontroller

Figure IV: Ultrasonic Sensor HC-SR04

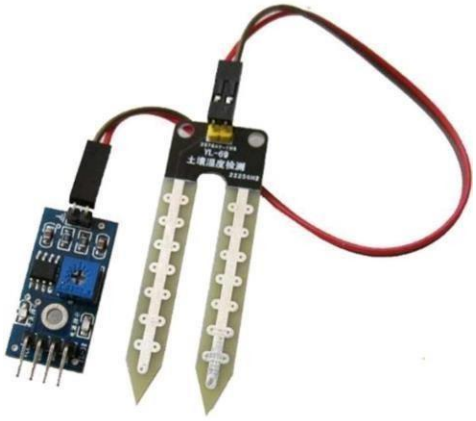

Figure V: Soil Moisture Sensor Detection

The researchers will utilize the Arduino microcontroller as the central component to power the waste segregation machine and soil moisture sensor detection for precise and efficient differentiation between dry and wet plastic waste.

GSM Module

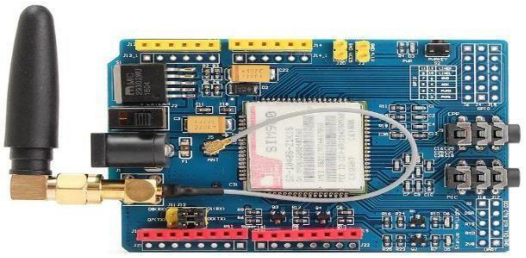

Figure VI: GSM Shield

The researcher incorporates a GSM module, enhancing the waste segregation machine with real-time connectivity for alert purposes, ensuring timely notifications about bin status, and facilitating streamlined waste management in public areas.

Conveyor Belt

Figure VII: Conveyor pad & Idle Roller

The researchers are utilizing a conveyor belt in the “Wasebin” system, enabling the automated movement of waste items for efficient segregation and processing within the machine.

DC motor with gearbox

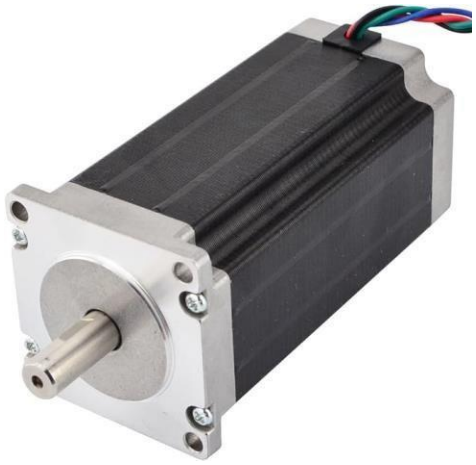

Figure VIII: DC motor with gear box

The researcher utilizes a DC motor with gear box for the conveyor belt in the “Wasebin” project, enabling the continuous movement of waste items through the system for effective segregation and processing.

Limitations

The study is limited to City Social Circle (Keg-Keg), and the results may not be applicable to other locations. Additionally, the study only focuses on evaluating the "Wasebin" technology and does not account for other factors that may influence waste management practices, such as human behavior, social norms, and policies. Lastly, the technology's effectiveness in segregating other types of waste apart from the dry and wet plastic waste items mentioned in the study may not be fully explored.

LITERATURE REVIEW

Review of related literature/studies/systems

Related literature

Solid waste not only affects the person living nearby it but also used to affect others too. Actually, solid waste, due to the formation of the leachate and gases, affects the water under the landfill site and also the air around it. Due to the formation of methane and other gases at the landfill site, the atmosphere gets distorted suddenly and harms the surrounding environment (Harit Priyadarshi, Sarv Priya, Ashish Jain, 2020).

Philippines is beset with challenges accompanying the increasing population that exacerbates the problem of solid waste. Under the Local Government Code of the Philippines 1991 (Republic Act 9003 [RA 9003]), it is expected that Local Government Units (LGUs) perform their role in implementing programs mandated by the national government, including the Solid Waste Management (SWM) program. RA 9003 or the Ecological Solid Waste Management Act 2000 was enacted to address the worsening garbage problem, along with its environmental and health impacts (Miriam Ramirez Nguyen, 2020).

Waste segregation is a crucial part in the waste management chain since it allows for successful reuse, recycling, and recovery. Solid waste management is critical for environmental conservation and human well-being. The improper management of waste disposal may cause contamination of soil, water, and air, which will create an inconvenience to human beings. (Kihila 2021),

A portion of the trash individuals produce is biodegradable, some is recyclable, and some is not one or the other. Waste segregation involves separating wastes according to how they are handled. Separating garbage at the unloading locations requires more time and work. A Spontaneous Waste Segregator (SWS), which is a cheap and easy-to-use solution for an isolation framework for family units (Rakib,et.al., 2021).

Conventional solid waste management systems have several shortcomings in terms of late unloading, hindrance in new techniques, lacking in throughput, less access to actual data, and many more. Therefore, an advanced approach is needed to overcome all existing problems in the waste collection process. (Aniqa Bano, Ikram Ud Din, Asma A. Al-Huqail, 2020).

Related Studies

Solid waste management is considered a pressing global issue calling for an immediate response from the government and its people. The Philippines has a continuously rising amount of waste and is expected to further increase in the succeeding years. As reviewed, associated problems with solid waste management in the country include an increasing amount of solid waste, weak law implementation, scarcity of sanitary landfills, and improper disposal. (Ericson E. Coracero1, RB J. Gallego, Kristine Joy M. Frago, Ruel Joseph R. Gonzales, 2021).

The use of technology in waste management can reduce the environmental impact of waste and improve the quality of life for city residents. The model can also optimize waste collection routes and schedules, leading to cost and time savings. (Arun Manupati, Humera Begum, 2023).

Mitigating the garbage and maintaining the cleanliness requires a smartness-based waste management system. The need for proper waste management does not end with just collection and proper disposal of garbage. It continues to the level of landfills and the amount that we can possibly recycle. (Praveen Kumar Gupta, Vidya Shree, 2019).

By understanding this errand, we can maintain a strategic distance from the pollution realized by dustbins. Additionally, the shocking smell can be decreased or avoided in the light of social events and hardship before it rots. (Chitluri Sai Srikanth, 2019).

As a result, smart waste management systems form an essential part of the establishment of smart cities. The conventional method of manually monitoring the waste in waste bins is a tedious process and uses a lot of human effort, time, and cost, which can easily be avoided with the current innovations (Aarati Medehal, Aniruddha Annaluru, 2020).

Related System

Garbage collection and dumping are tedious jobs. Though lots of garbage bins are installed in various places nowadays, very few people use them. Moreover, when garbage becomes full, it takes days to dump it, hence it overflows (Biswajit Jana, Pragnapan Roy, 2019).

When the garbage reaches the maximum level, a notification will be sent to the corporation's office, and then the employees can take further actions to empty the bin. By using this system, people do not have to check all the systems manually; instead, they will get a notification when the bin gets filled (Prof. Vaibhav Anil Kamble, Shivaraj Manik Gaikwad, 2022).

The main objectives of the project are to develop a monitoring system that uses an ultrasonic sensor to show the level of garbage in the trash cans in real-time, a GSM module to alert the administrator when the level of garbage in the trash can reaches the maximum level, and a garbage can that opens on its own using a servomotor and laser sensor when it detects nearby objects (Jerome B. Sigongan, Hamer P. Sinodlay, 2023).

The ultrasonic sensor has been tested and observed, and it detects the level of each bin. The signal of the sensor affects the sending of notifications and the reboot of the Arduino-Based Waste Detector with Alarm System. When the garbage is thrown in the wrong bin, the alarm triggers and segregates the waste on its designated bin (Ma. Xena L. Bautista, Cheerobie B. Aranas, Rina J. Arcigal, 2023).

The generation of solid wastes in households is inevitable, and so it is imperative that families, together with government units and agencies, are made accountable in the

successful implementation of waste management initiatives. (M.R. Limon, J.P.C. Vallente, N.C.T. Corales, 2020).

Among its critical provisions are the formal devolution of waste management to local levels, including forced closure of illegal dumpsites, investment in facilities, and reduction and proper treatment of solid wastes (Domingo, Sonny N., Manejar, Arvie Joy A. 2021).

Public trash cans are overflowing with waste in several cities. The garbage collector frequently fails to pick up the trash cans on time. As a result, it emits a foul odor that is hazardous to human health (Jackielou S. Mapa-Madlos, Jenecris Tapdasan, Jeffrey Serdeña, Marjorie Ramsey, Imee U. Anton, 2022).

The smart bin solution enables cleaning operators to identify real-time cleanliness problems. This solution enables to assist the growing need to increase general productivity and cleanliness in waste segregation (Mary Jane C. Samonte, Shaddi Hercules Baloloy, Carl Kenneth J. Datinguinoo, 2021).

Synthesis

Based on related literature that the researchers gathered, waste segregation emerges as a crucial aspect of the waste management process, enabling effective reuse, recycling, and recovery. Proper solid waste management is essential for environmental conservation and human well-being, as improper disposal can lead to soil, water, and air contamination, causing inconveniences for communities.

The introduction of innovative solutions, such as the Spontaneous Waste Segregator, highlights the importance of practical and cost-effective approaches to waste segregation at the household level. Overall, addressing solid waste management issues requires a collective effort, incorporating policy implementation, public awareness, and innovative solutions to mitigate the environmental and health impacts associated with improper waste

disposal. Additionally, it is crucial to recognize that the challenge of waste segregation is not unique to the Philippines.

Globally, many regions grapple with similar issues in managing solid waste effectively. The improper sorting and disposal of waste pose environmental and health risks worldwide, impacting ecosystems, water sources, and air quality. Therefore, addressing waste segregation is a universal concern that requires collaborative efforts, innovative solutions, and a commitment to sustainable practices on a global scale.

	Waste Bin Monitoring System Using Integrated Technologies	**Monitoring The Smart Garbage Bin Filling Status: An IOT Application Towards Waste Management**	**Wasebin: A Microcontroller-Based Waste Segregation Machine**
Provide status real time bin	✓		✓
Segregate Garbage			✓
Notify the utilities.		✓	✓
Promote Sanitation Environmental	✓	✓	✓

Table I: The graph shows the difference of projects relating to waste segregation.

Based on the graph, it can be concluded that “Wasebin” is the most innovative and effective system for efficient waste management and promoting a cleaner, healthier environment. This system has the capability to segregate different types of garbage, which is a crucial aspect of proper waste disposal. With "Wasebin," one can easily monitor the status of their bins in real-time, allowing for quick and easy maintenance. This system is perfect for anyone who wants to take responsibility for their waste and ensure it is disposed of properly.

Another popular waste management system, Waste Bin Monitoring, also offers real-time monitoring of bin status. Although it may not have the same capabilities as “Wasebin” when it comes to segregating different types of garbage, it is still a great option for those who want to stay on top of their waste management.

On the other hand, Smart Garbage Bin Filling Status is slightly different from the other two systems. It offers a route to the landfill, which can be helpful for those who are unsure of where to dispose of their waste. However, it doesn't offer the same level of monitoring and segregation as "Wasebin," which makes it less effective in terms of overall waste management.

Overall, it is evident that “Wasebin” is the best waste management system available. With its innovative features and capabilities, it offers a more efficient and effective way to manage waste. Whether looking to reduce their carbon footprint or simply wants to take responsibility for their waste, “Wasebin” is the perfect solution.

WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE

Overview of the project

Using current state technology, CENRO focuses on dry plastics, such as snack and candy wrappers. Wet plastics will go through a process for non-recyclable or non-exchangeable materials. The difficult part is separating the wet and dry materials. The researchers aim to enhance waste segregation precision with the help of soil moisture sensor detection to effectively distinguish between the two. The GSM shield is used to notify when the collection has reached its capacity.

System design specification

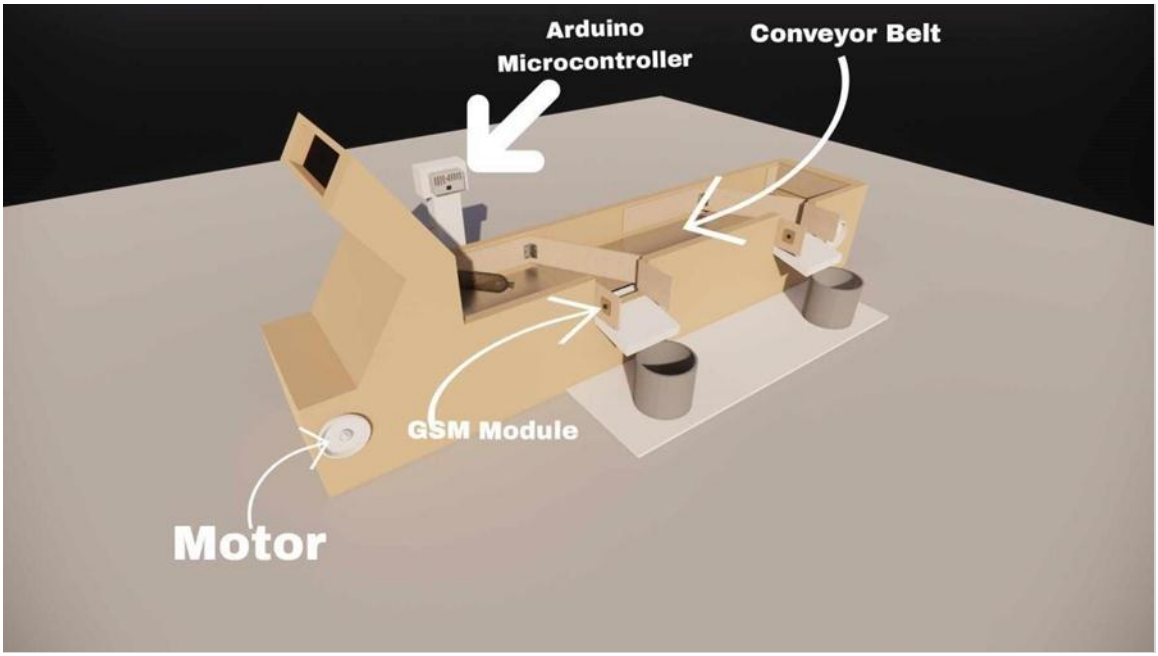

Figure IX: The image shows the main components of the machine

Figure X: The image shows the actual components of the machine put together

The researchers programmed the arduino uno and the soil moisture sensor to detect wet and dry materials. These components were then mounted on plywood for material detection. The conveyor and roller were installed on the plywood to move the trash. The motor powers the roller to activate the movement of the machine.

METHODOLOGY

Methodology

The researcher would use Agile Hardware Development (AHD), which is a subset of Agile Methodology. It is compatible with Modified Agile Hardware Development (MAHD), which was developed for the hardware version. This method consists of phases of planning, designing and prototyping, iterative development, testing, user feedback and iteration, manufacturing, monitoring and maintenance, and improvement. The iterative and incremental approach of using AHD is beneficial for researchers as it allows them to create hardware prototypes for continuous testing. This approach helps in speeding up the research process and also helps in identifying and fixing design flaws early on, which contributes to making the hardware more resilient and reliable overall.

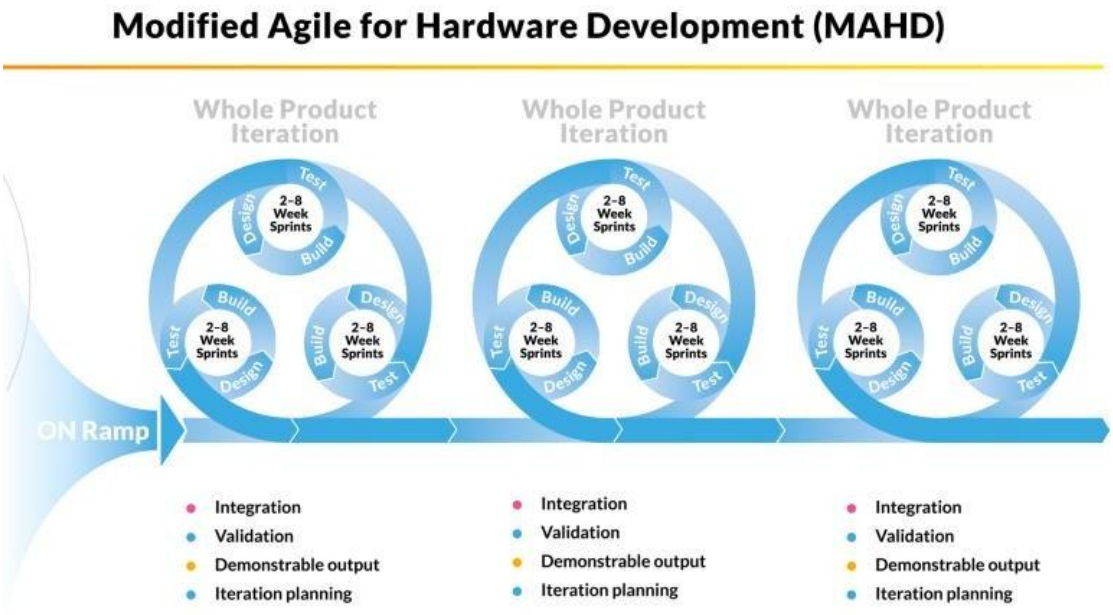

Figure XI: Agile Hardware Development

Phase 1: Planning

In this phase, the researcher is planning a strategy to create a hardware solution called “Wasebin" that will assist the City Environment and Natural Resources Office (CENRO) in their environmental preservation initiative and help reduce the use of plastic. Creating "Wasebin" will be highly advantageous for CENRO in achieving their goals. To develop the concept of hardware that can sort dry and wet plastics, the researchers need to have a thorough understanding of the hardware components, equipment, and budget system. It is essential to plan the concept carefully to ensure successful implementation.

Phase 2: Design and Prototyping

During this phase, the researchers will design and specify the equipment to be used at this stage. The tools needed to complete the project include an Arduino microcontroller with two (2) parts: a soil moisture sensor and a GSM shield, a conveyor belt, rollers, motors, swing arms, and an outer cover that protects the Wasebin’s internal components. To determine whether the bin is separating wet and dry plastics, the researchers will build a miniature prototype of the device.

Phase 3: Iterative Development

During this stage, the researchers will continue to work on developing and improving the hardware throughout this phase in order to create a machine that is more efficient in the future and to create advanced functionalities.

Phase 4: Testing

The machine will be used and tested by the researchers to show that it serves the intended purpose of separating plastics into two (2) categories: wet and dry plastics. Additionally, it will demonstrate the capabilities of its alert and notification systems for utility staff who are on duty.

Phase 5: User feedback and iteration

During this stage, the proponents must consult users, including students, vendors, and city hall staff. The host, the City Environment and Natural Resources Office (CENRO), will be one of the judges using the hardware; they must also suggest any improvements to make the device more efficient than it was in its first year of use.

Phase 6: Monitoring and maintenance

After the deployment, the hardware problem needs to be resolved by the researchers. If testing reveals no issues, for instance, there could still be an unanticipated malfunction. Therefore, the people responsible for maintaining the device should have a routine in place to prevent serious harm and injuries in the event of a mechanical malfunction.

Phase 7: Improvement

In this final stage, the researchers are still searching for ways to improve the device because it will still change into different figures and have features that enhance the hardware's look and functionality to attract more users and make it stand out from the original Wasebin.

Hardware/Software

Hardware Components:

Arduino Uno Sensor:

The Arduino Uno Sensor serves as the core hardware component for the "GeniusBin." It is responsible for detecting the type and quantity of waste deposited into the bin. Equipped with various sensors, the Arduino Uno plays a pivotal role in data acquisition and initial processing.

GSM Module Sensor:

The GSM Module Sensor provides essential network connectivity to the GeniusBin, enabling seamless data transfer and facilitating remote monitoring. This component ensures real-time communication, allowing for immediate alerts and updates on the bin's status.

Power Supply:

The power supply is a critical component, ensuring continuous operation of the GeniusBin. It can be either a direct power source or a rechargeable battery, providing flexibility in deployment locations and minimizing interruptions in service.

Conveyor Belt:

The incorporation of a conveyor belt is crucial for the efficient movement of waste items within the bin. As items move along the belt, the system can carry out various tasks related to processing or waste identification. This feature enhances the overall functionality of the waste separation process.

Motor Dynamo:

The motor dynamo is an additional hardware component that complements the conveyor belt system. It plays a key role in facilitating the movement of waste items and ensuring a steady flow along the conveyor belt. The motor dynamo contributes to the seamless functioning of the waste processing system.

Software Components:

Notifications/Alerts:

The software includes a notification/alert system that communicates with users when the bin requires attention. This feature ensures that waste management personnel and relevant authorities are promptly informed when the bin is full or needs maintenance, facilitating timely intervention.

Data Processing Algorithm:

A sophisticated data processing algorithm is implemented in the software to analyze sensor data. This algorithm is designed to classify and identify different types of waste accurately. Through continuous learning and adaptation, the algorithm contributes to the system's efficiency in waste segregation.

User Interface:

This interface enables users to remotely monitor and manage the smart bin. Waste management personnel can access real-time data, receive alerts, and efficiently plan collection routes based on the bin's status.

RESULTS AND DISCUSSIONS

ALPHA TESTING

Quality Tester	John Paul H. Clarito Laurence Christopher C. Dugay Franz John Chloe T. Navalta Christian Paul L. Valdez
Date:	October 2, 2024
List of Pages to be Tested:	Segregation, Sms, Garbage Bin
Summary Report:	System and design working properly.

Segregation			
Questions	Yes	No	Comments
Is the soil moisture sensor consistently reliable in detecting wet plastic?	✓		`This segregation are working
Does the DC motor activate when garbage is detected?	✓		
Does the servo motor swing when dry plastic is detected?	✓		
Does the servo motor swing when wet plastic is detected?	✓		
Is the waste segregation system able to correctly identify and sort different types of waste?	✓		

Table 2. Segregation

SMS			
Questions	Yes	No	Comments
Is the GSM module functional?	✓		This sms are working
Can the GSM module send SMS notifications?	✓		
Is the GSM module reliable for sending notifications?	✓		
Does the GSM module provide timely updates on bin status?	✓		

Table 3: SMS

Garbage Bin			
Questions	Yes	No	Comments
Is the automatic garbage bin functional?	✓		This Garbage bin are working
Does the garbage bin close when it is full?	✓		
Is the garbage bin's automatic mechanism reliable?	✓		

Table 4: Garbage Bin

BETA TESTING

Likert's Scale

RANGE	SCALE	RATING
4.51 – 5.00	Strongly Agree (SA)	5
3.51 – 4.50	Agree (A)	4
2.51 – 3.50	Neutral (N)	3
1.51 – 2.50	Disagree (D)	2
1.00 – 1.50	Strongly Disagree (SD)	1

Table 5: Likert's Scale Interpretation

Range Formula:

$$\mathbf{x} = \frac{\textbf{Rating (number of vote)}}{\textbf{Total Respondents}}$$

Criteria	Strongly Agree(5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
Segregation					
The Soil Moisture Sensor are consistently detect wet plastic.	11	15	4		
The real-time bin status feature enhances my trust	10	16	3	1	

in the waste management system detected.					
I agree that humanizing the waste management process can lead to better public engagement	20	8	2		
Having a machine that identifies wet plastics can help educate users about proper waste disposal.	21	4	4	1	
The effectiveness of this machine will depend on user cooperation.	16	11	3		
I believe that a machine like this can inspire other innovations in waste management.	22	6	2		
I believe that this machine can serve as a model for future waste management solutions.	21	5	4		
I agree that having clear instructions on the bin will help users properly segregate waste.	20	6	4		
The servo motor will swing to detect the dry plastic.	12	12	6		
The servo motor will swing to detect the wet plastic.	16	7	7		
The Waste Segregation System is an effective way to identify and sort the different types of waste correctly.	19	9	1	1	
SMS					
The GSM Module is an effective to function and notify the status of the garbage bin.	11	12	6	1	

The GSM Module is an effective way to send SMS notifications.	13	10	6	1	
The GSM Module is accurately send notifications.	10	13	6	1	
The GSM Module is an effective way to update on bin status timely.	14	13	3		
I feel that the GSM shield indicator is essential for effective waste segregation.	17	9	4		
It's important for a waste bin to minimize overflow incidents through automated messaging.	15	10	5		
The ability to receive alerts about bin status would encourage more responsible waste disposal.	17	8	5		
I agree that timely notifications can prevent overflow and maintain cleanliness in public spaces.	17	7	5	1	
Garbage Bin					
The Automatic Garbage Bin are accurately function the different types of waste.	10	12	7	1	
The Garbage Bin is an effectively close if the garbage is full.	9	14	7		
The Garbage Bin is an effective of automatic mechanism of a system.	16	11	2	1	
I believe that such a waste bin can help reduce the workload of utility staff.	19	7	3	1	
The concept of a smart waste bin is appealing to	21	6	3		

me.					
I think that real-time monitoring of waste bins can help local governments optimize collection routes.	21	4	4	1	
I agree that a waste bin should have an appealing design to encourage usage.	20	8	1	1	
I think that the introduction of smart waste bins could lead to a cultural shift in waste management practices.	18	9	2	1	

Table 6. Likert's Result

Segregation

$$\text{Q1 } 4.23 = \frac{5(11)+4(15)+3(4)+2(0)+1(0)}{30}$$

$$\text{Q2 } 4.17 = \frac{5(10)+4(16)+3(3)+2(1)+1(0)}{30}$$

$$\text{Q3 } 4.60 = \frac{5(20)+4(8)+3(2)+2(0)+1(0)}{30}$$

$$\text{Q4 } 4.50 = \frac{5(21)+4(4)+3(4)+2(1)+1(0)}{30}$$

$$\text{Q5 } 4.43 = \frac{5(16)+4(11)+3(3)+2(0)+1(0)}{30}$$

$$\text{Q6 } 4.67 = \frac{5(22)+4(6)+3(2)+2(0)+1(0)}{30}$$

$$\text{Q7 } 4.57 = \frac{5(21)+4(5)+3(4)+2(0)+1(0)}{30}$$

$$\text{Q8 } 4.53 = \frac{5(20)+4(6)+3(4)+2(0)+1(0)}{30}$$

$$\text{Q9 } 4.20 = \frac{5(12)+4(12)+3(6)+2(0)+1(0)}{30}$$

$$\text{Q10 } 4.30 = \frac{5(16)+4(7)+3(7)+2(0)+1(0)}{30}$$

$$\text{Q11 } 4.53 = \frac{5(19)+4(9)+3(1)+2(1)+1(0)}{30}$$

$$\text{Agree (A) } 4.43 = \frac{4.23+4.17+4.60+4.50+4.43+4.67++4.57+4.53+4.20+4.30+4.53}{11}$$

Segregation	Range	Scale	Rating
The Soil Moisture Sensor are consistently detect wet plastic.	4.23	A	4
The real-time bin status feature enhances my trust in the waste management system	4.17	A	4
I agree that humanizing the waste management process can lead to better public engagement.	4.60	SA	5
Having a machine that identifies wet plastics can help educate users about proper waste disposal.	4.50	A	4
The effectiveness of this machine will depend on user cooperation.	4.43	A	4
I believe that a machine like this can inspire other innovations in waste management.	4.67	SA	5
I believe that this machine can serve as a model for future waste management solutions.	4.57	SA	5
I agree that having clear instructions on the bin will help users properly segregate waste.	4.53	SA	5
The servo motor will swing to detect the dry plastic.	4.20	A	4

The servo motor will swing to detect the wet plastic.	4.30	A	4
The Waste Segregation System is an effective way to identify and sort the different types of waste correctly.	4.53	SA	5

Table 7. Segregation

In this table, some of the people and students have agreed and the rest are strongly agreed. The total of the range of every question is 4.43 which is agree (A) with the rating of 4. Therefore, most students and people are considered that a machine like this can inspire other innovations in waste management.

SMS

$$\text{Q1 } 4.10 = \frac{5(11)+4(12)+3(6)+2(1)+1(0)}{30}$$

$$\text{Q2 } 4.17 = \frac{5(13)+4(10)+3(6)+2(1)+1(0)}{30}$$

$$\text{Q3 } 4.07 = \frac{5(10)+4(13)+3(6)+2(1)+1(0)}{30}$$

$$\text{Q4 } 4.37 = \frac{5(14)+4(13)+3(3)+2(0)+1(0)}{30}$$

$$\text{Q5 } 4.43 = \frac{5(17)+4(9)+3(4)+2(0)+1(0)}{30}$$

$$\text{Q6 } 4.33 = \frac{5(15)+4(10)+3(5)+2(0)+1(0)}{30}$$

$$\text{Q7 } 4.40 = \frac{5(17)+4(8)+3(5)+2(0)+1(0)}{30}$$

$$\text{Q8 } 4.33 = \frac{5(17)+4(7)+3(5)+2(1)+1(0)}{30}$$

$$\text{Agree } 4.28 = \frac{4.10+4.17+4.07+4.37+4.43+4.33+4.40+4.33}{8}$$

SMS	Range	Scale	Rating
The GSM Module is an effective to function and notify the status of the garbage bin.	4.10	A	4
The GSM Module is an effective way to send SMS notifications.	4.17	A	4
The GSM Module is accurately send notifications.	4.07	A	4
The GSM Module is an effective way to update on bin status timely.	4.37	A	4
I feel that the GSM shield indicator is essential for effective waste segregation.	4.43	A	4
It's important for a waste bin to minimize overflow incidents through automated messaging.	4.33	A	4
The ability to receive alerts about bin status would encourage more responsible waste disposal.	4.40	A	4
I agree that timely notifications can prevent overflow and maintain cleanliness in public spaces.	4.33	A	4

Table 8. SMS

In this table, all the people and students are Agree. The total of the range of every

question is 4.28 which is Agree (A) with the rating of 4. Therefore, all the people and students are considered that the GSM shield indicator is essential for effective waste segregation.

Garbage Bin

$$\text{Q1 } 4.03 = \frac{5(10)+4(12)+3(7)+2(1)+1(0)}{30}$$

$$\text{Q2 } 4.07 = \frac{5(9)+4(14)+3(7)+2(0)+1(0)}{30}$$

$$\text{Q3 } 4.40 = \frac{5(16)+4(11)+3(2)+2(1)+1(0)}{30}$$

$$\text{Q4 } 4.47 = \frac{5(19)+4(7)+3(3)+2(1)+1(0)}{30}$$

$$\text{Q5 } 4.60 = \frac{5(21)+4(6)+3(3)+2(0)+1(0)}{30}$$

$$\text{Q6 } 4.50 = \frac{5(21)+4(4)+3(4)+2(1)+1(0)}{30}$$

$$\text{Q7 } 4.60 = \frac{5(20)+4(8)+3(1)+2(1)+1(0)}{30}$$

$$\text{Q8 } 4.47 = \frac{5(18)+4(9)+3(2)+2(1)+1(0)}{30}$$

$$\text{Agree } 4.39 = \frac{4.03+4.07+4.40+4.47+4.60+4.50+4.60+4.47}{8}$$

Garbage Bin	Range	Scale	Rating
The Automatic Garbage Bin are accurately function the different types of waste.	4.03	A	4
The Garbage Bin is an effectively close if the garbage is full.	4.07	A	4
The Garbage Bin is an effective of automatic mechanism of a system.	4.40	A	4
I believe that such a waste bin can help reduce the workload of utility staff.	4.47	A	4
The concept of a smart waste bin is appealing to me.	4.60	SA	5
I think that real-time monitoring of waste bins can help local governments optimize collection routes.	4.50	A	4
I agree that a waste bin should have an appealing design to encourage usage.	4.60	SA	5
I think that the introduction of smart waste bins could lead to a cultural shift in waste management practices.	4.47	A	4

Table 9. Garbage Bin

In this table, all students and people agreed. The total of the range of every question is 4.39 which is agree (A) with the rating of 4. Therefore, all the students and people are considered that the concept of a smart waste bin is appealing to them. They agreed that a waste bin should have an appealing design to encourage usage.

Overall Likert's Scale Pie Graph

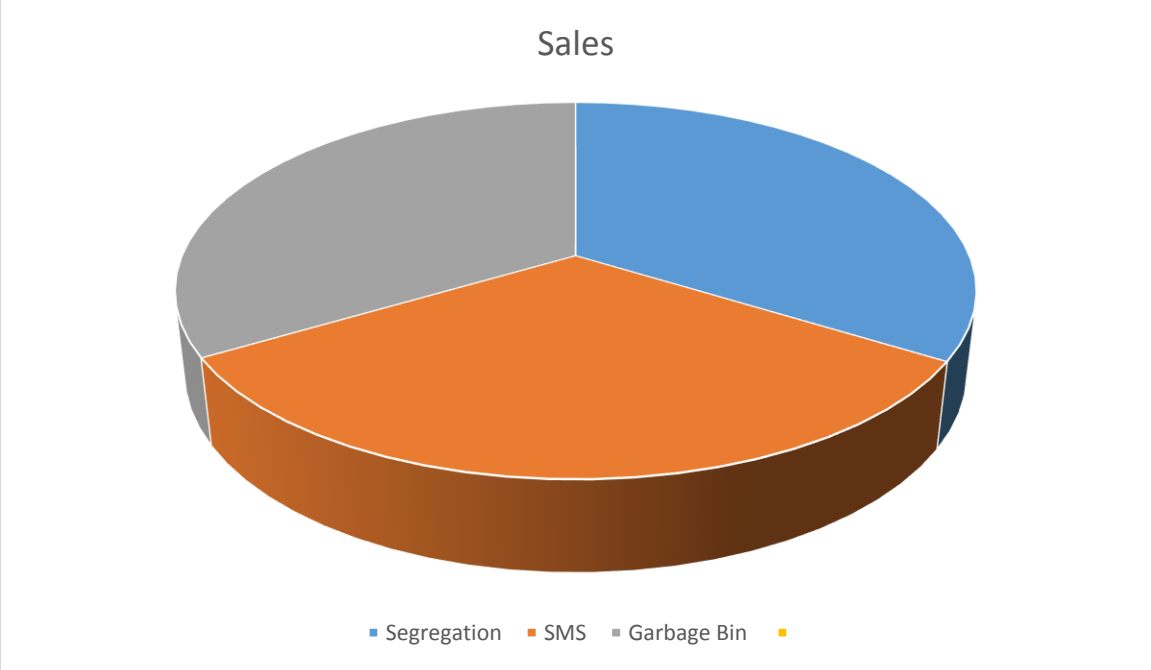

Figure XII. Likert's Scale Result

The pie chart visualizes the Garbage Bin, SMS, and Segregation categories. All three have the same size according to the pie chart. Segregation has the highest rating, followed by Garbage Bin. The lowest rating is for SMS. Overall, the pie chart indicates that students and people rate Segregation can inspire other innovations in waste management, while others have a positive perception of Garbage Bin and SMS.

CONCLUSION

The microcontroller-based waste segregation machine is a device that separates wet and dry plastic. It uses a microcontroller or Arduino for waste segregation solutions and monitoring. The soil moisture sensor detects the difference between dry and wet plastic waste. This system helps with collecting and sorting garbage, making it easier for staff.

This technology can also detect unknown waste when it cannot be recognized. It sends an SMS notification to update the bin status in real-time. It simplifies sorting compared to manual methods. Many people dispose of their trash improperly, mixing waste types incorrectly. This system can reduce the environmental impact and promote a healthier ecosystem.

In conclusion, the microcontroller-based waste segregation machine is an effective tool for separating wet and dry plastic waste. If the sensor cannot detect the type of waste, it will be placed in an "unknown" container. The SMS notifications help prevent bins from overflowing after segregation. This system promotes recycling and reduces the environmental impact in urban areas like City Social Circle (Keg-Keg).

REFERENCES

Afolalu, A. S. Ikumapayi, O. M. Oloyede O. R. Ogundipe, A. Noiki, A. (2021). Development of Smart Waste Bin for Solid Waste Management [Research Paper]. Retrieved from https://www.researchgate.net/

Aguila, J. M. U., Dimayuga, H. S., Pineda K. O. F., Magwili, G. V., (2019). Development of Smart Waste Bin with Integrated Volume and Weight Sensor [Research Paper]. Retrieved from https://ieeexplore.ieee.org/abstract/document/9072885/authors

Bano, A., Din, I. U., Al-Huqail A. A., (2020). AIoT-Based Smart Bin for Real-Time Monitoring and Management of Solid Waste [Research Paper]. Retrieved from https://www.hindawi.com/

Bano, A., Din, I. U., Al-Huqail, A. A., (2020). AIoT-Based Smart Bin for Real-Time Monitoring and Management of Solid Waste [Research Paper]. Retrieved from https://www.hindawi.com/journals/sp/2020/6613263/#conclusion

Bashir, A., Banday, S., (2013). Concept Design and Implementation of Automatic Waste Management System[Research Paper]. Retrieved from https://www.researchgate.net/publication/

Biswajit, J. Pragnapan, R. Supratim, S. Suvasis, P. Riya, S. (2019). GSM controlled location specific garbage collecting Smart-bin [Research Paper]. Retrieved from https://ieeexplore.ieee.org/abstract/document/8877007

Domingo, S. N., Manejar, A. J. A., (2021). An analysis of regulatory policies on solid waste management in the Philippines: Ways forward [Research Paper]. Retrieved from https://www.econstor.eu/handle/10419/241050

Dugdhe, S., Shelar, P., Jire, S., Apte, A., (2016). Efficient Waste Collection System [Research Paper]. Retrieved from https://www.researchgate.net//

Ericson E. Coracero1, RB J. Gallego, Kristine Joy M. Frago, Ruel Joseph R. Gonzales, (2021) . A Long-Standing Problem: A Review on the Solid Waste Management in the Philippines [Research Paper]. Retrieved from https://www.Researchgate.net/

Flores M. G., Tan, J., (2020). Literature Review of Automated Waste Segregation System Using Machine Learning: A Comprehensive Analysis [Research Paper]. Retrieved from https://www.semanticscholar.org/

Gupta, P. K., Shree, V., Rajendran, S., (2019). The Use of Modern Technology in Smart Waste Management and Recycling: Artificial Intelligence and Machine Learning

[Research Paper]. Retrieved from https://link.springer.com/chapter/10.1007/978-3-030-12500-4_11

Ishoka, O. A. (2008). Problems of Solid Waste Disposal and Management in Ughelli Delta State, Nigeria [Research Paper]. Retrieved from https://scirp.org/

Kamble, V. A., Gaikwad, S. M., Misal, G. S., (2022). Smart Garbage Disposal System [Research Paper]. Retrieved from https://www.ijeast.com/

Kumar, N. S. Vuayalakshmi, B. Prarthana, J. R. Shankar, A. (2016). IOT Based Garbage Alert System Using Arduino UNO [Research Paper]. Retrieved from https://ieeexplore.ieee.org/

Lazaro, J. P., Rubio, A. J. M., (2014). Solar Powered Electronic Trash Can [Research Paper]. Retrieved from https://www.academia.edu/40632275/Solar_Powered_Electronic_Trash_Can

Leton, T. G., Omotosho, O. (2004). Landfill Operation in the Niger Delta Region of Nigeria [Research Paper]. Retrieved from https://www.sciencedirect.com/

Longo, E., Sahin, F. A., Redondi, A. E. C., Bolzan, P., Bianchini, M., Maffei, S., (2021). A 5G-Enabled Smart Waste Management System for University Campus [Research Paper]. Retrieved from https://www.mdpi.com/

Mapa-Madlos, J. S., Tapdasan, J., Serdeña, J., Ramsey, M. Anton, I. U., (2022). Sensor-Based Garbage Monitoring System and Application Development in Magallanes Agusan Del Norte [Research Paper]. Retrieved from https://ieeexplore.ieee.org/abstract/document/10109414

Md Abdullah Al Rakib, Md. Sohel Rana, Md. Moklesur Rahman, Fysol Ibna Abbas. (2021). Dry and Wet Waste Segregation and Management System [Research Paper]. Retrieved from https://www.Researchgate.net/

Medehal, A., Annaluru, A., Bandyopadhyay, S., Chandar, T. S., (2020). Automated Smart Garbage Monitoring System with Optimal Route Generation for Collection.[Research Paper]. Retrieved from https://ieeexplore.ieee.org/abstract/document/9239002

Pamintuan, M., Mantiquilla, S. M., Reyes, H., Samonte, M. J., (2019). I-BIN: An Intelligent Trash Bin for Automatic Waste Segregation and Monitoring System [Research Paper]. Retrieved from https://ieeexplore.ieee.org/

Patel, D., Patel, F., Patel, S., Patel, N., Shah, D., Patel, V., (2021). Garbage Detection Using Advanced Object Detection Techniques [Research Paper]. Retrieved from https://ieeexplore.ieee.org/

Saha, H. N., Auddy, S., Pal, S., Kumar, S., Pandey, S., Singh, R., et al. (2017). Waste Management Using Internet of Things (IoT) [Research Paper]. Retrieved from https://ieeexplore.ieee.org/

Singonan, J. B., Sinodlay, H. P., Cuizon, S. X. P., Redondo J. S., Macapulay, M. G., Bulahan-Undag, C. O., et al. (2023). GULP: Solar-Powered Smart Garbage Segregation Bins with SMS Notification and Machine Learning Image Processing [Research Paper]. Retrieved from https://browse.arxiv.org/pdf/2304.13040.pdf

Swaminathan, M. (2018). How Can India's Waste Problem See a Systematic Change [Research Paper]. Retrieved from https://www.researchgate.net/

Samonte, M. J. C., Baloloy, S. H., Datinguinoo C. K. J., (2022). e-TapOn: Solar-Powered Smart Bin with Path-based Robotic Garbage Collector [Research Paper]. Retrieved from https://ieeexplore.ieee.org/abstract/document/9436763

Srikanth, C. S., Ryudu, T. B., Radhika, J. Anitha, R., (2019). Smart Waste Management Using Internet of Things (IoT) [Research Paper]. Retrieved from https://www.ijitee.org/

Huh, J. H., Choi, J. H., Seo, K., (2021). Smart Trash Bin Model Design and Future for Smart City [Research Paper]. Retrieved from https://www.mdpi.com/

Harit Priyadarshi, Sarv Priya, Ashish Jain, Shadab Khursheed. (2020) A Literature Review on Solid WasteManagement: Characteristics, Techniques,Environmental Impacts and Health Effectsin Aligarh City", Uttar Pradesh, India [Research Paper]. Retrieved from https://www.Researchgate.net/

Jaime Cuauhtémoc Negrete. (2023). Arduino in agriculture and the teaching of mathematics [Research Article]. Retrieved from https://www.medcraveonline.com/

Worku Adefris, Shimeles Damene, Poshendra Satyal. (2023). Household practices and determinants of solid waste segregation in Addis Ababa city, Ethiopia [Research Paper]. Retrieved from https://www.nature.com/

APPENDICES

APPENDIX A. GANTT CHART

MONTH / ACTIVITY	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Planning										
Design and Prototyping										
Iterative Development										
Testing										
User Feedback and Iteration										
Manufacturing										
Improvement										

MONTH / ACTIVITY	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Planning						
Design and Prototyping						
Iterative Development						
Testing						
User Feedback						
Manufacturing						
Improvement						

APPENDIX B. ACTUAL THESIS EXPENSES

THESIS EXPENSES

Quantity	Specifics	Approximate Cost	Actual Cost
Lafvin Basic Starter kit for Arduino Uno R3 with Tutorial Code Breadboard Jumper Wire led Diodes Obstacle	1 Piece	P 649	P 692
Sim800L V2 5V Wireless GSM GPRS Module	1 Piece	P 335	P 355
Ultrasonic Sensor Distance Measuring Module	1 Piece	P 49	P 49
Sim900A V4.0 Kit Wireless Extension Module	1 Piece	P 349	P 349
Circuitrocks Breadboard	1 Piece	P 55	113
DC Gear Motor 6V 12RPM	1 Piece	P 299 – 349	P 299 – 349
Plywood	1 piece	P 770	P 770
Nail	10 pieces	P 45	P 45
Glue	1 piece	P 70	P 70
electrical tape	3 pieces	P 60	P 60
Liha	1 piece	P 50	P 50
1/2 x 1/8 stick	5 pieces	P 192	P 192

Screw	1 piece	P 90	P 90
Motor	1 piece	P 343	P 343
Arduino uno DIT	2 pieces	P 600	P 600
Servo	2 pieces	P 89	P 89
relay	1 piece	P 42	P 42
22awg wire	1 piece	P 50	P 50
bisagra	2 pieces	P 20	P 20
bin	2 pieces	P 180	P 180

Prepared by:

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Approved by:

Joel M. Pascua **Denmark M. Dela Cruz**

APPENDIX C. USER'S MANUAL

Appendix C. User's Manual

Preparation

- **Assemble the Components:**
    - Ensure all components (Arduino microcontroller, ultrasonic sensor, soil moisture sensor, GSM module, conveyor belt, and DC motor with gearbox) are properly assembled and connected.

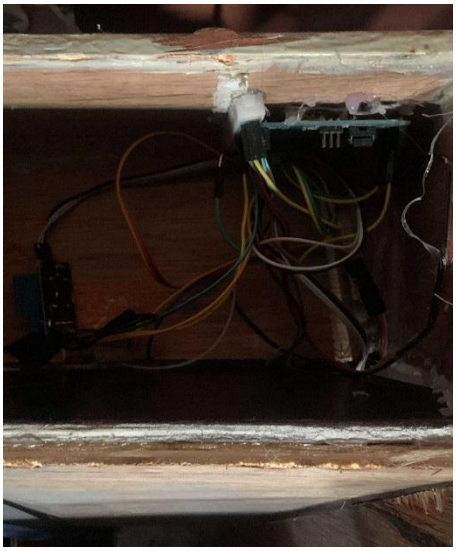

Figure XIII: All of Components

- **Insert SIM Card:**
    - Insert a valid SIM card into the GSM module to enable real-time notifications.

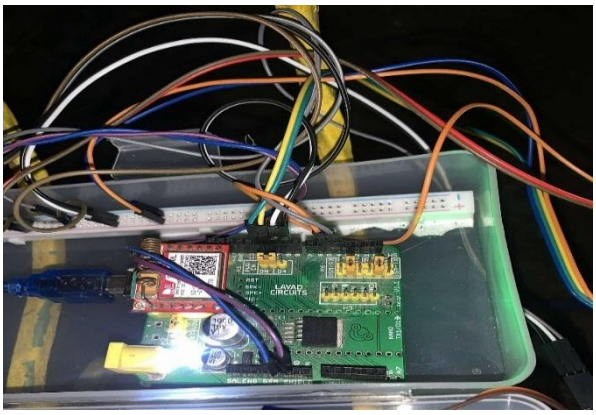

Figure XIV: SIM Card

- **Power**

  Connection:

  - Connect the Arduino microcontroller to a suitable power source to power the entire system.

Figure XV: Connection of the Arduino microcontroller

Throwing Plastic Waste:

When you throw a plastic waste item into the Wasebin system, the ultrasonic sensor detects the presence of the waste.

Figure XVI: Throwing Plastic Waste

Detecting Waste:

The ultrasonic sensor activates upon detecting the waste item, signaling the system to begin the segregation process.

Figure XVII: Ultrasonic Sensor

Segregation Process:

The soil moisture sensor evaluates the waste to determine if it is dry or wet.

If the waste is identified as dry, the system activates a swing arm.

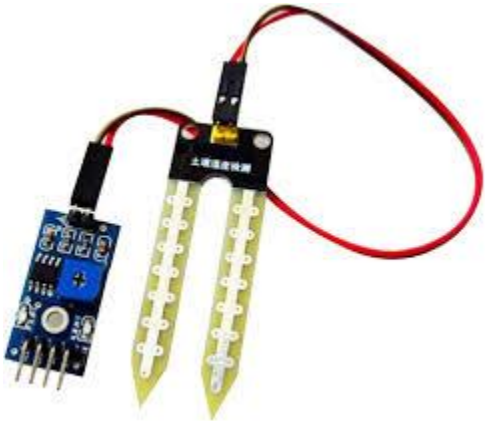

Figure XVIII: Soil Moisture Sensor

Delivering Waste:

The swing arm pushes the dry plastic waste onto the conveyor belt.

The conveyor belt, powered by a DC motor with a gearbox, moves the waste towards the designated bin.

Figure XIX: Swing Arm

Automatic Bin Closing:

As the waste is deposited into the bin, the system monitors the bin's capacity.

When the bin reaches its full capacity, the system automatically closes the bin to prevent overflow.

Figure XX: Automatic Bin Closing

Sending SMS Notification:

Once the bin is full and closed, the GSM module sends an SMS notification to inform you that the bin requires collection.

This real-time notification ensures timely waste management and helps maintain cleanliness.

Figure XXI: GSM module

APPENDIX D. CURRICULUM VITAE OF RESEARCHERS

Curriculum Vitae of

JOHN PAUL H. CLARITO

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09610334563

EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	2021 - presemt	STI College San Jose
TechVoc	N/A	N/A
High School	2015 - 2018	San Jose City National High School
Elementary	2009 - 2014	San Jose East Central School

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
October 2021	Photo Editor / Watcher	Derriek's Shop
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
month year		
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
Coding in Java/C#	Proficient	2021 - Present
Photo Editing	Proficient	2019 - Present
Video Editing	Novice	2018 - Present

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
month year	
month year	
month year	
month year	

Listed in reverse chronological order (most recent first).

Curriculum Vitae of

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Manggahan 2, Brgy Balante Science City of Muñoz Nueva Ecija dugay
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09064457622

EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	2019 - present	STI College San Jose
TechVoc	N/A	N/A
High School	2013 - 2018	Muñoz National High School
Elementary	2006-2012	Muñoz North Central School

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
N/A	N/A	N/A
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
N/A	N/A	N/A
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
Photo Editing	Proficient	2019 – present
Video Editing	Proficient	2020 – present
Networking	Proficient	2023

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
N/A	N/A
month year	
month year	
month year	

Listed in reverse chronological order (most recent first).

Curriculum Vitae of

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09655716479

EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	2021 - presemt	STI College San Jose
TechVoc	N/A	N/A
High School	2015 - 2019	Saint John's Academy
Elementary	2007 - 2015	Saint John's Academy

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
N/A	N/A	N/A
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
month year		
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
Coding in Java/C#	Proficient	2021 - Present
Encoder	Proficient	2022 - present
Schedule of temple	Novice	2022 - present

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
N/A	
month year	
month year	
month year	

Listed in reverse chronological order (most recent first).

Curriculum Vitae of

CHRISTIAN PAUL L. VALDEZ

Brgy. Tabulac, San Jose CIty, Nueva Ecija
valdez.255347@sanjose.sti.edu.ph
09457980661

EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	2021 - presemt	STI College San Jose
TechVoc	N/A	N/A
High School	2009 - 2014	Sacred Heart Academy of Lupao Inc.
Elementary	2004 - 2008	Luisa Madrid Methodist School

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
October 2022	Assistant Ward Clerk	The Church of Jesus Christ of Latter day Saints
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
month year		
month year		
month year		
month year		

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
Coding in Java/C#	Proficient	2021 - Present
Encoder	Proficient	2022 - present
Schedule of Temple	Novice	2022 - present

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
N/A	
month year	
month year	
month year	

Listed in reverse chronological order (most recent first).

APPENDIX E. ACCOMPLISHMENT AND CONSULTATION FORM

ACCOMPLISHMENT AND CONSULTATION FORM

INSTRUCTION: List all the activities, improvements or accomplishments that has been made in your Capstone Design Documentation and System/Prototype. This form may be reproduced as you go along with your thesis. This form should be submitted to your Capstone Design Adviser every week.

Thesis Title: SMART GARBAGE BIN: AN EFFICIENT WASTE MANAGEMENT DISPOSAL
Week Number: 9

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
1.) Change the second paragraph of introduction. [illegible] flow of the overview of ideas. – Add more about microcontroller applications in diff. areas. 2.) Background of the problem: – Rephrase the statement of [illegible] or provide a concluding statement to clarify the points. 3.) Current state of technology – based it with the [illegible] observation and add [illegible] statement. 4.) Finalize the objectives. 5.) Scope: include all components of the device (actual), with image.	* Due on week 11 – Friday Nov. 10
Prepared by: John Paul H. Clarito/October 27, 2023; Laurence Christopher C. Dugay/ October 27, 2023	Franz John Chloe T. Navalta/ October 27, 2023; Christian Paul L. Valdez/ October 27, 2023
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 10/27/2023	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: 10/27/2023

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ACCOMPLISHMENT AND CONSULTATION FORM

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Thesis Title: WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE
Week Number: 7

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
Servo motor trigger – use ultra sonic to sense object in the conveyor	– Done with minimal correction
Case refinement – improve the design of machine opening & cover	– For actual development
Prepared by: John Paul H. Clarito/April 02, 2024; Laurence Christopher C. Dugay/April 02, 2024	Franz John Chloe T. Navalta/April 02, 2024; Christian Paul L. Valdez/April 02, 2024
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 04/ /2024	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: / /

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Thesis Title: WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE
Week Number: 5

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
* Complete the task checklist	– March 19
* Test the consistency of humidity sensor	
* Phase 1 of mechanical parts: – Conveyor & motor	
Prepared by: John Paul H. Clarito/March 08, 2024; Laurence Christopher C. Dugay/March 08, 2024	Franz John Chloe T. Navalta/March 08, 2024; Christian Paul L. Valdez/ March 08, 2024
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 03/ /2024	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: / /

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Thesis Title: WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE
Week Number: 8 11

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
Microcontroller – Refine the connection of humidity and ultrasonic sensor	– Due May 10 → Done
– Include additional motor for the conveyor and ultra sonic as trigger	– 1st done by May 17
Housing – first actual build	– May 10 → No output
Prepared by: John Paul H. Clarito/May 5, 2024; Laurence Christopher C. Dugay/May 5, 2024	Franz John Chloe T. Navalta/May 5, 2024; Christian Paul L. Valdez/ May 5, 2024
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 05/14/2024	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: / /

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Thesis Title: WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE
Week Number: 4

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
* Determine the circuit design of humidity sensor to microcontroller w/ LED as output.	Due date: – March 8, 2024 (Friday)
* Program to connect sensor & LED.	
* Provide a checklist of task to accomplish. c/o Christian	– March 5 (incomplete)
Prepared by: John Paul H. Clarito/March 01, 2024; Laurence Christopher C. Dugay/March 01, 2024	Franz John Chloe T. Navalta/March 01, 2024; Christian Paul L. Valdez/ March 01, 2024
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 03/ /2024	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: / /

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ACCOMPLISHMENT AND CONSULTATION FORM

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Thesis Title: BINGENTUS: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE
Week Number: 11

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
Introduction: – Include the information of [illegible] (San Jose City)/CENRO. Background of the problem: – Use Grammarly for sentence construction. Current state of technology: – Change the first paragraph. Objectives: – Revise: it should answer the identified problems. Scope: – [illegible] – [illegible] in the document. Format: – Change the footer	To be check on week 12: Nov. 17, 2023 9:00 AM
Prepared by: John Paul H. Clarito/November 10, 2023; Laurence Christopher C. Dugay/ November 10, 2023	Franz John Chloe T. Navalta/ November 10, 2023; Christian Paul L. Valdez/ November 10, 2023
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 11/10/2023	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: 11/10/2023

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ACCOMPLISHMENT AND CONSULTATION FORM

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Thesis Title: WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE
Week Number: 6

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
* Activity checklist update	To be check on April 2 → Done
* Digital design of housing & mechanical components.	→ In progress
* Set-up a trigger of moisture sensor.	
* Make the servo motor respond according to the reading of moisture.	→ Done
Prepared by: John Paul H. Clarito/March 19, 2024; Laurence Christopher C. Dugay/March 19, 2024	Franz John Chloe T. Navalta/March 19, 2024; Christian Paul L. Valdez/ March 19, 2024
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 03/5 /2024	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: / /

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Thesis Title: SMART GARBAGE BIN: AN EFFICIENT WASTE MANAGEMENT DISPOSAL
Week Number: 8

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
Changes of Introduction, Background of the problem, Overview of the current state of the technology, Objectives of the study and Scope and limitations of the study.	Introduction: • Information about the waste process. • Explanation of hardware, microcontroller and other features. • 90% cited. Background of the problem • All mentioned of the problem • Interview Overview of the current technology • What are they doing? • Based on observation. Objective of the study • Mentionable measurable. • Make it per module. • Functions of the project and its purpose. Scope and limitations of the study • What hardware will you be using? • Description of project hardware with picture.
Prepared by: John Paul H. Clarito/October 20, 2023; Laurence Christopher C. Dugay/ October 20, 2023	Franz John Chloe T. Navalta/ October 20, 2023; Christian Paul L. Valdez/ October 20, 2023
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 10/20/2023	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: 10/20/2023

ACCOMPLISHMENT AND CONSULTATION FORM | FT-ARA-039-00 | PAGE 1 OF 1

ACCOMPLISHMENT AND CONSULTATION FORM

INSTRUCTION: List all the activities, improvements or accomplishments that has been made in your Capstone Design Documentation and System/Prototype. This form may be reproduced as you go along with your thesis. This form should be submitted to your Capstone Design Adviser every week.

Thesis Title: WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE
Week Number: 3

ACTIVITY/ ACCOMPLISHMENT	REMARKS/ COMMENTS/ SUGGESTIONS/ DELIVERABLES and DUE DATE
• Purchasing and waiting for all the materials needed for our thesis project. • Need a complete design for the thesis project. • Assist in checking all the work; what else needs to be done? • List what the necessary designs are.	Done.
Prepared by: John Paul H. Clarito/February 23, 2024; Laurence Christopher C. Dugay/February 23, 2024	Franz John Chloe T. Navalta/February 23, 2024; Christian Paul L. Valdez/ February 23, 2024
Checked by: Mr. Nestor N. Quiambao Jr., Thesis Adviser, Date Signed: 03/ /2024	Noted by: Denmark M. Dela Cruz, Thesis Coordinator, Date Signed: / /

ACCOMPLISHMENT AND CONSULTATION FORM | FT-ARA-039-00 | PAGE 1 OF 1

THESIS PROPOSAL EVALUATION FORM

THESIS ADVISER	STI SCHOOL	SCHOOL YEAR/TERM
Joel M. Pascua	STI College San Jose	SY2324-2T
THESIS TITLE		
WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION MACHINE		
NAME OF GROUP MEMBERS		
John Paul H. Clarito	Franz John Chloe T. Navalta	
Laurence Christopher C. Dugay	Christian Paul L. Valdez	

INSTRUCTIONS:

Fill out the form by checking the appropriate box that needs to be revised by the thesis group. Write your comments/suggestions/recommendations if necessary.

RECOMMENDATION:

☐ Thesis proposal is ***approved with no revisions***.
☒ Thesis proposal is ***approved with revisions****. (Ensure that all revisions are met to be accepted as thesis)

***CORRECTIONS/REVISIONS:**

☐ Inappropriate thesis title.

☐ The study was already conducted.

☐ Incompleteness or incorrectness of written research problems and objectives in any of the following (*Indicate reasons*):
- ☐ Inappropriate statement of the research problems (form).
- ☐ Problems incorrectly state what has to be solved by the study.
- ☐ Objectives state the incorrect solutions to the problem(s).
- ☐ Objectives of the study do not conform to S-M-A-R-T (Specific, Measurable, Attainable, Realistic, and Time-bounded) criteria.
  - ☐ The specific objectives do not state precise and definite details about the project.
  - ☐ The criteria cannot be quantified for measuring the accomplishment(s).
  - ☐ The goals set by the proponents are not achievable through available means.
  - ☐ The proposed solution is not complex enough to justify a thesis.
  - ☐ It is not possible to time-bound the objectives.
- ☐ Other (Please specify):

☐ Scope does not discuss all important modules or features of the study which were essential in the development of the project.

☐ Limitations of the study are incorrectly identified which make the contents of the document inconsistent to what has to be covered. (**Should provide justifications on the limitations**)

☐ Discussions which are not the original ideas are not properly cited and the bibliographical listing contains inadequate amount of references. (**Do not simply copy from sources**)

☒ Others (Please specify):

THESIS PROPOSAL APPROVAL FORM

THESIS ADVISER	STI SCHOOL	SCHOOL YEAR/TERM
Joel M. Pascua	STI College San Jose	SY2324-2T
THESIS TITLE		
WASEBIN: A MICROCONTROLLER-BASED WASTE SEGREGATION		
NAME OF GROUP MEMBERS		
John Paul H. Clarito	Franz John Chloe T. Navalta	
Laurence Christopher C. Dugay	Christian Paul L. Valdez	

RECOMMENDATION:

☒ Thesis proposal is ***approved with no revisions***.
Thesis Proposal is approved if all the necessary comments/revisions/suggestions are met based on the Thesis Proposal Evaluation Results.

Remarks:

Fix the spacing of the title on the title page.

☐ Thesis proposal is ***for revisions***.
Thesis Proposal is for revision if the given comments/revisions/suggestions are not met based on the Thesis Proposal Evaluation Results.

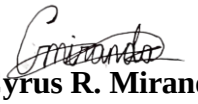
Remarks:

Click or tap to enter remarks.

Note: Please provide a copy of this form in your Project Implementation documentation.

CERTIFICATE OF ENGLISH EDITING

This thesis entitled: Wasebin: A Microcontroller-Based Waste Segregation Machine prepared and submitted by John Paul H. Clarito; Laurence Christopher C. Dugay; Franz John Chloe T. Navalta; and Christian Paul L. Valdez, in partial fulfillment of the requirements of STI College San Jose for the degree Bachelor of Science in Computer Science, has been edited to ensure that the language is clear and free of errors. The logical presentation of ideas and the structure of the paper were also checked during the editing process.



Cyrus R. Miranda
***Staff,* CLSU - Institute for Climate Change and Environmental Management (ICCEM) Bachelor of Arts in Literature**

ENDORSED BY:

Joel M. Pascua
Thesis Project Adviser

NOTED BY:

Mark O. Binuya
Thesis Project Coordinator

November 30, 2024

HOST COMPANY'S ACCEPTANCE FORM

This thesis titled: **Wasebin: A Microcontroller-Based Waste Segregation Machine prepared and submitted by John Paul H. Clarito; Laurence Christopher C. Dugay; Franz John Chloe T. Navalta; and Christian Paul L. Valdez**, in partial fulfillment of the requirements of STI College San Jose for the degree Bachelor of Science in Information Systems, has been presented and is recommended for acceptance and approval.

Joel M. Pascua
Thesis Adviser

NOTED BY:

Mark O. Binuya
Thesis Coordinator

Francis Jorge R. Bondoc
Academic Head

Reviewed and accepted by Community Environment
and Natural Resources Office
in accordance with the anticipated form and function
agreed upon during the proposal phase of the project.

APPROVED:

Glenda R. Garcia
Pollution Control Officer
Community Environment and Natural Resources Office
San Jose City, Nueva Ecija