

**DEVELOPMENT OF AN AUTOMATIC LGU-BASED SOLID WASTE SEGREGATION PROTOTYPE USING ARDUINO****Princess Joy S. Macalisang**BSCS Faculty, College of Computer Science,  
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**ABSTRACT**

Waste segregation remains a persistent challenge in educational institutions due to inconsistent compliance, human error, and reliance on manual sorting practices. This study developed an Automatic LGU-Based Solid Waste Segregation Prototype using Arduino to automate the classification of plastic, metal, and biodegradable materials at Blancia College Foundation, Incorporated. Following a developmental research design guided by the engineering design process, the prototype integrated inductive, capacitive, and ultrasonic sensors with an Arduino Uno microcontroller and servo-driven sorting mechanisms. The system was programmed using C/C++ to detect material types, execute classification logic, and automatically direct waste into appropriate bins. LCD displays, LED indicators, buzzer alerts, and full-bin detection enhanced user interaction and operational efficiency. Effectiveness was evaluated through a structured questionnaire administered to fifteen respondents, including faculty, students, and staff. Data were analyzed using frequency distribution, weighted mean, and grand mean. The prototype achieved a consolidated grand mean of 4.97, interpreted as Very High Effectiveness, demonstrating accurate waste detection, reliable mechanical response, user-friendly operation, and strong potential for institutional and community-level application. Findings indicate that Arduino-based automation improves sorting accuracy, reduces manual labor, and promotes environmental sustainability. The prototype supports compliance with ecological solid waste management principles under Republic Act No. 9003 and offers a scalable model for future LGU-level implementation, providing both technical feasibility and practical utility in fostering sustainable campus operations.

**Keywords:**

Waste Segregation, Automation, Microcontroller, Sensors, Solid Waste Management, Environmental Sustainability, LGU-Based System, Embedded System, Smart Waste Management

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**INTRODUCTION**

One of the most serious problems in contemporary society, especially in educational facilities, is waste management as a big number of people produce great volumes of waste every day. The segregation of waste in the form of plastic, metal and bio waste needs to be done properly to achieve environmental sustainability and to minimize the health risks. In case of poor implementation of segregation, the recyclable goods are wasted, the pollution is enhanced, the health risks are developed. Waste segregation in Blancia College Foundation Incorporated is still performed manually in the institution. In their day-to-day operations, students and staff produce several wastes that fall into several categories such as plastic, metal, and bio waste materials. Although trash bins have been provided, segregation is not always maintained meaning that the different types of wastes are mixed up. The result of this makes the environment polluted, the maintenance staff overworked and recyclable and reusable materials disposed of improperly. Segregation in manual form is also ineffective, time consuming and subject to human error. Automation can be one of the possible solutions to this issue with the development of technology. With the assistance of an Arduino-based system, it is possible to create cost-efficient, efficient, and reliable prototypes that will manage to recognize and isolate waste materials

automatically. Incorporation of sensors that can tell the difference between plastic, metal, and bio waste will greatly save human labor, increase accuracy and efficiency of the entire waste management process in the institution. The given thesis project title, which is the Development of an Automatic LGU-based Solid Waste Segregation Prototype Using Arduino, will help solve the problem of manual segregation, developing an automatic system. The given system should foster environmental sustainability, reduce the overall load of the school maintenance personnel, and be an innovative example of waste management actions that can be implemented not only within schools but in other, larger communities.

### LITERATURE

Poor waste disposal in the Philippines is a topical problem of the country in terms of health, hygiene, and the environment. The Republic Act No. 9003 or the Ecological Solid Waste Management Act of 2000 stipulates that the local government units must implement systematic, comprehensive and ecological waste management programs that would promote segregation at the source, recycling, and composting. Nevertheless, even with such a law, there are issues with the establishment of effective segregation mechanisms in the country under the pretext of ignorance, the lack of effective technological infrastructure, and inconsistent waste collection (DENR, 2020). Scientists and local environmental agencies have stressed the necessity of incorporating automation and digitalization in handling wastes and reducing the human factor during sorting operations. Microcontroller-related systems like Arduino are also being considered in scholarly literature as a solution towards encouraging the notion of smart garbage separation in schools and communities (Lopez & Dela Cruz, 2021). Municipal Ordinance No. 11th -41-2023, "AN ORDINANCE UPDATING THE SOLID WASTE MANAGEMENT CODE OF MOALVE ZAMBOANGA DEL SUR" also known as the Solid Waste Management Code of the Municipality of Molave, Zamboanga del Sur. This ordinance shall apply to all residential houses, industrial, financial and commercial establishments such as eating places like cafeterias, restaurants, public markets, groceries, institutions like hospitals, schools, churches, public and private offices and agricultural areas.

Waste management has been reported as a crucial environmental problem all over the world. The United Nations Environment Programme (2021) noted that inappropriate waste segregation is one of the major factors that lead to environmental pollution and health risks to the population. There has been significant promise in automation technologies such as artificial intelligence, and microcontrollers systems that can enhance waste 7 classification and recycling efficiency. Sharma et al. (2020) states that the operation of microcontroller-based systems (Arduino) is used to improve safety and reliability of waste sorting, minimizing human efforts, and improving the overall waste sorting. These research papers indicate the movement of technology-based sustainability practices in the world.

A few research projects on the development of automated waste segregation systems have been done within the Philippine setting. A research article by Bautista et al. (2022) of the Technological University of the Philippines created a prototype that creates a system based on Arduino and infrared sensors to identify biodegradable and nonbiodegradable waste. Their system proved to be a better sorting system than manual sorting. On the same note, De Vera and Santos (2023) suggested a waste segregation system with ultrasonic sensors to establish waste levels in bins and encourage cleanliness and awareness of students at school. These articles indicate the increasing popularity of the implementation of automation to the local solutions of waste management. Bayta, J. D., Bagat, J. N., Auino, J. A., & Jaspio, R. C. A. (2025). International Institute of Academic Research Incorporated. In their article, Gupta and Singh (2020) described a completely automated waste sorting system with inductive sensors detecting metals and capacitive sensors detecting plastics. Their prototype was very successful in sorting different solid waste types with high accuracy justifying the use of automated technologies on waste management. The other system created by Sharma et al. (2020) merges infrared (IR), moisture, and inductive sensors to determine waste or biodegradable, non-biodegradable, and metallic. According to their research, sensor-based segregation methods have an accuracy rate of 85 percent hence proving efficient. This study presents the development of an Arduino-based automatic waste segregation system that utilizes infrared, moisture, and metal sensors to classify waste into different categories such as wet, dry, and metal. The system automates the detection and 8 sorting process, improving efficiency and reducing human intervention, which supports sustainable waste management practices by Anbalakan, M., Subramanian, N., Siva, T., Srijith, K., and Srisurya, R. (2021). system for automatically separating garbage. International Journal of Engineering Computations Research and Intellectual Progress.

### OBJECTIVES

The main objective of the study is to design and develop an Automatic LGU-based Solid Waste Segregation Prototype using Arduino for Blanca College Foundation, Incorporated. (BCFI). It includes the following:

- 1) To determine typical waste to be produced in the institution that is LGU-based waste especially plastic, metal and biomaterials.
- 2) To design and develop a prototype that will automatically separate and recognize plastic, metal, and bio waste with the help of Arduino-based sensors.
- 3) To test and analyze the validity and effectiveness of the prototype in a separate and categorize the plastic, metal, and bio waste.
- 4) To determine the weaknesses of the systems developed regarding operation, capacity, and accuracy.

### **METHODOLOGY**

This study's methods will be discussed in this chapter, including the research methodology, research environment, research respondents, data gathering procedure, data gathering instruments, statistical treatment of data and ethical considerations.

#### **Research Methodology**

The research method employed in this study was developmental research whereby the design, construction and analysis of a plastic, metal, and bio waste segregation system was done. The methodology followed the engineering design process as it consists of problem identification, system design, prototyping, testing and assessment. The recognition and classification of the waste materials was done with sensors, microcontrollers and mechanical sorting mechanisms that placed the materials in the right kind of containers. Evaluation of the effectiveness of the prototype was done through trial operation in the form of accuracy, efficiency and reliability.

#### **Research Environment**

BCFI school campus was used because the facility was the best location to conduct the study because it had the necessary facilities, instrumentation, and equipment to do mechanical fabrication and electronics assembly. Prototyping tools, inductive, capacitive and moisture sensors, microcontrollers (Arduino/ESP) and fabrication equipment were available to the users. The procedure was experimented in the controlled laboratory condition, which was like the real trash segregation process, with plastic, metal and biodegradable materials as the samples.

#### **Research Respondents**

The respondents to the study were chosen people who tested the effectiveness and functionality of the developed system. These included: Computer Science Faculty members to provide technical advice on technical design and functionality. Students and staff as the potential users of the system in school or community. The purposive sampling method was used to capture the information of respondents who had adequate knowledge about the waste management practices and had a rudimentary knowledge regarding the automation system

#### **Data Gathering Procedure**

The researchers had a systematic approach to the collection of information. To begin with, they created the prototype of waste segregation during the stage of the system development with the help of sensors and a microcontroller. Following this, during the prototype testing, pretests were carried out where various samples of waste materials like plastic, metal, and biodegradable materials were fed into the system to test the accuracy of the system in sorting the waste materials. The stage of observation and recording implied registering responsiveness, speed and efficiency of the prototype in segregating the waste. The survey on evaluation was then conducted by providing the respondents, which was made up of the students, with a series of structured questionnaires to gauge the effectiveness, usability and possible applications of the system. Data collection was conducted in two phases: First, Technical Testing where waste samples were inserted into the system. Observations were recorded using a performance checklist focusing on accuracy, speed, and consistency, and User Evaluation where a structured questionnaire consisting of sixteen (16) items was distributed to respondents after system demonstration and testing. The questionnaire was divided into four sections: Prototype Functionality, Reliability and Performance, Usability, and Overall Evaluation. Respondents rated each statement using a five-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1).

#### **Data Gathering Instrument**

The primary instrument used was a structured evaluation questionnaire based on a five-point Likert scale. The instrument measured respondents' perceptions regarding system effectiveness. A performance checklist was also used to document actual system operation during prototype testing. The survey questionnaire was also sent

to the respondents as a validated tool to gauge their perception about the system since its usability, reliability and effectiveness in real-world use. Observations and test results were also recorded using documentation tools like cameras.

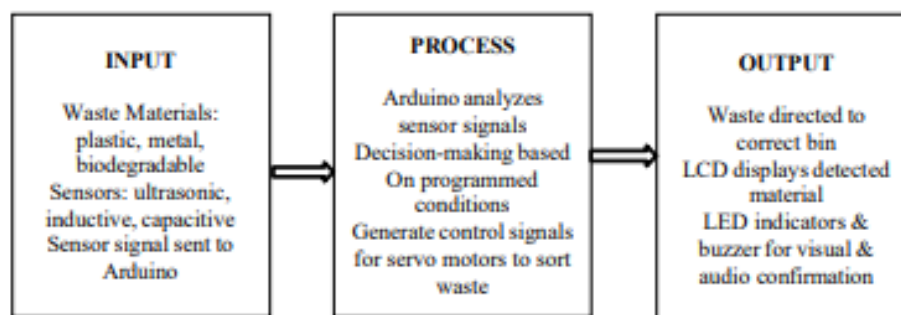
### Statistical Treatment of Data

The data gathered from the evaluation questionnaires were analyzed using descriptive statistical methods, specifically frequency distribution, weighted mean, and 16 grand means. A five-point Likert scale was used: • 5 – Strongly Agree • 4 – Agree • 3 – Neutral • 2 – Disagree • 1 – Strongly Disagree The frequency distribution determined the number of responses per scale category. The weighted mean was computed using the formula:  $f = \text{frequency of responses}$   $x = \text{weight assigned to each response}$   $N = \text{total number of respondents}$  To determine the overall effectiveness of each category and the entire system, the grand mean was calculated by averaging the weighted means of all items under each variable. The following scale was used to interpret the computed mean scores: • 4.50 – 5.00 = Very High Effectiveness • 3.50 – 4.49 = High Effectiveness • 2.50 – 3.49 = Moderate Effectiveness • 1.50 – 2.49 = Low Effectiveness • 1.49 = Very Low Effectiveness These statistical treatments enabled the researchers to objectively evaluate the functionality, reliability, usability, and overall performance of the prototype based on respondents' assessments.

### Ethical Considerations

In this research work, the ethical standards were followed in designing, developing, testing, and evaluating Automatic LGU-based Solid Waste Segregation Prototype with the use of Arduino. The research was a study of human subjects thus informing 17 obtained in all the faculty members, students and staff who participated in the research to evaluate the system. The participants had been made aware of the rationale of the study, as well as that they were participating in a voluntary activity and that they could pull out and exit any time without any repercussions. The survey questionnaires did not gather any personal identifying information, which would allow anonymity and confidentiality of responses. Another aspect that was addressed by the researchers of the study was that the prototype should not be physically dangerous to the users. Electronic parts were also well insulated and assembled to avoid any electrical hazard or overheating, or mechanical damage. Experiments were done under controlled setting working in a laboratory to ensure safety standards. The system was also geared toward solid waste materials that were dry to prevent possible contamination and biological hazards. Waste handling and testing were conducted properly about sanitation. In addition, the research followed policies in institutional research and adhered to the environmental laws, especially those provisions that are in tandem with Republic Act No. 9003 that advocates solid waste management that is eco-friendly. The study sought to aid the sustainability of the environment without damaging both society and university. Each of the mentioned sources and other studies were cited in a proper way to ensure the academic integrity and prevent plagiarism. The researchers were very responsible, transparent, and put in mind the welfare of the people when the project was carried out.

### System Overview



**Figure 1. IPO Model**

The developed system is an Arduino-based automatic waste segregation prototype designed to sort plastic, metal, and biodegradable waste without manual intervention. At the center of the system is the Arduino Uno, which serves as the main controller. It receives signals from different sensors, processes the information, and activates the sorting mechanism. The system uses an ultrasonic sensor to detect the presence of an object, an inductive sensor to identify metal materials, a capacitive sensor to detect plastic, and a moisture-based sensing approach to recognize biodegradable waste. These components work together to ensure that waste is identified and sorted correctly. Input: The input stage consists of the waste materials plastic, metal, and biodegradable items and the data collected from sensors. Ultrasonic, inductive, and capacitive sensors detect the properties of

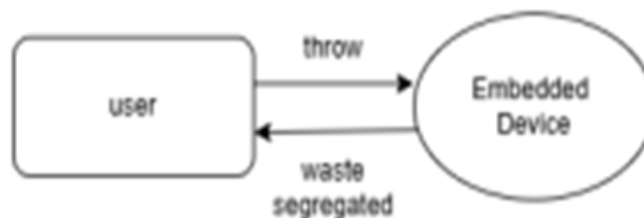
each waste item and convert them into electrical signals, which are sent to the Arduino microcontroller. This ensures the system has accurate, real-time information about the materials being sorted. **Process:** In the process stage, the Arduino acts as the decision-making unit. It analyzes sensor data, compares it against programmed conditions, and classifies each waste item. Based on the classification, the Arduino sends control signals to servo motors that physically direct the waste into the correct bin. This stage combines logical computation with mechanical action, making the system fully automated. **Output:** The output stage shows both physical results and user feedback. Sorted waste is placed into the appropriate bins, the LCD screen displays the detected material, and LED indicators and a buzzer provide visual and audio confirmation. This ensures users can easily verify the correct operation of the system.

#### System Objective

The main objective of this project is to develop an automatic waste segregation system that uses modern technology to make waste management more efficient and effective. This system is designed to utilize various sensors to automatically detect and classify different types of waste, such as metal, plastic, and biodegradable materials. By using ultrasonic, inductive, capacitive, and infrared sensors, the system can accurately identify the type of waste without requiring manual sorting. Once the waste is detected, the information is immediately displayed on an LCD screen, providing real-time monitoring for users and operators. To make the process fully automated, servo motors are used to control the movement of sorting mechanisms that direct the waste to the correct bin. A buzzer and indicator lights serve as notification tools to inform maintenance personnel about the system's operation, errors, or status updates. In addition, the maintenance personnel will monitor the system and perform timely maintenance or updates when needed. This ensures continuous and reliable system performance. Overall, the project aims to reduce manual labor, improve the accuracy of waste segregation, and support better environmental waste management through technology-driven solutions.

#### System Scope and Limitations

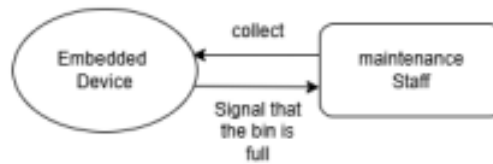
This project focuses on the development of a prototype system that automatically segregates plastic, metal, and biodegradable waste using an Arduino-based control unit. The scope of the system includes the design and construction of a small-scale working model that utilizes various sensors to detect and classify waste materials. For instance, inductive sensors are used to identify metallic objects, infrared sensors detect plastics, and moisture or organic sensors are employed to identify biodegradable waste. Once identified, the waste is directed into corresponding bins using motors or conveyor mechanisms, all controlled by the Arduino. The prototype is intended primarily for demonstration purposes, such as in academic projects or small community-based awareness programs and aims to reduce human involvement in basic waste segregation. However, the system has several limitations. It is designed only for prototype-level applications and cannot handle large volumes of waste, making it unsuitable for industrial or municipal use. The detection accuracy is limited due to the use of basic, low-cost sensors, which may struggle to correctly identify composite or mixed materials, such as plastic items containing metal parts. Additionally, the Arduino's limited processing power restricts the speed and complexity of operations, making the system slower compared to commercial waste segregation systems. The prototype also requires that waste be in solid, dry form and of manageable size to fit into the system's input compartment; irregularly shaped or wet materials may lead to sorting errors. Moreover, environmental factors such as lighting conditions and moisture may affect sensor readings, leading to inconsistencies in performance. Lastly, as a prototype the system may need frequent calibration and is not designed for long-term durability or continuous operation.



**Figure 2. DFD of the User**

Figure 2 illustrates a one-way interaction between a user and an embedded system. In this scenario, the user performs an action labeled "throw" directed at the embedded device. This "throw" likely represents the user sending a command, signal, or data to the embedded system to initiate a specific function or response. It highlights the user's role as the active initiator and the embedded system as the responsive entity. Overall, the

diagram emphasizes how users can control or communicate with embedded devices through deliberate input or interaction.



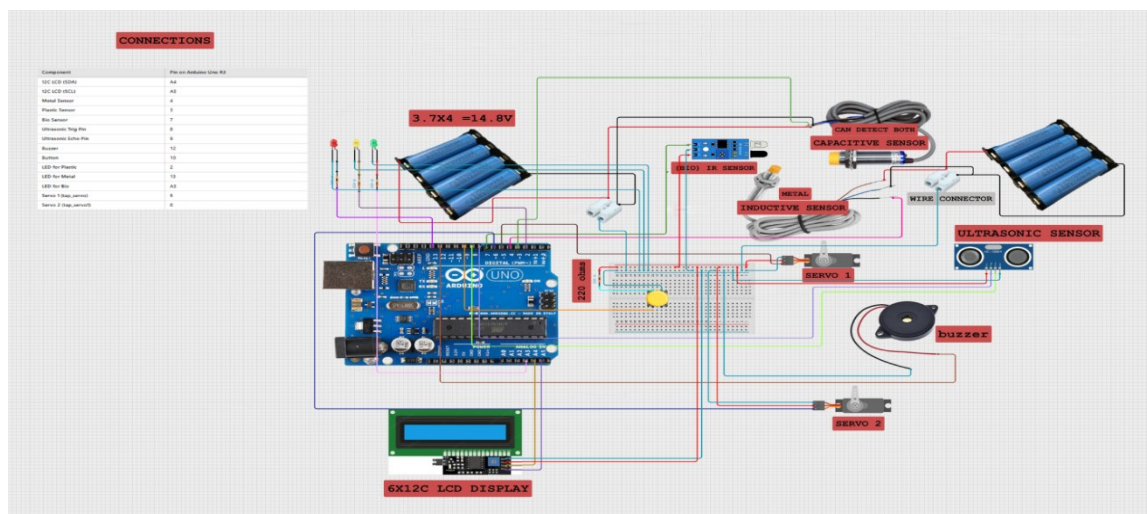
**Figure 3. DFD Maintenance Staff**

Figure 3 illustrates the interaction between embedded systems and maintenance teams in a facility. First, the embedded devices collect real-time data on equipment conditions and operational performance. This collected data is now collected by the maintenance staff, who analyze and monitor it to detect any issues or irregularities. Once issues are identified, the maintenance staff generates a report and forwards it to the maintenance personnel for appropriate action. Finally, the maintenance personnel use this report to perform necessary repairs or preventive maintenance, ensuring the system continues to run smoothly.



**Figure 4. DFD Maintenance Personnel**

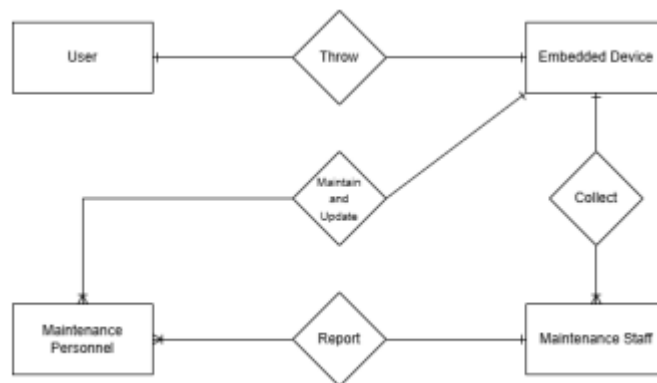
Figure 4 shows the relationship between maintenance personnel and embedded 23 systems. Here, the maintenance personnel play an active role in ensuring that the embedded devices are functioning properly. They regularly perform maintenance and system updates to keep the embedded infrastructure reliable and up to date. This process helps prevent potential malfunctions and improves system performance. As a result, the embedded



system can continue collecting accurate data and supporting operational activities efficiently.

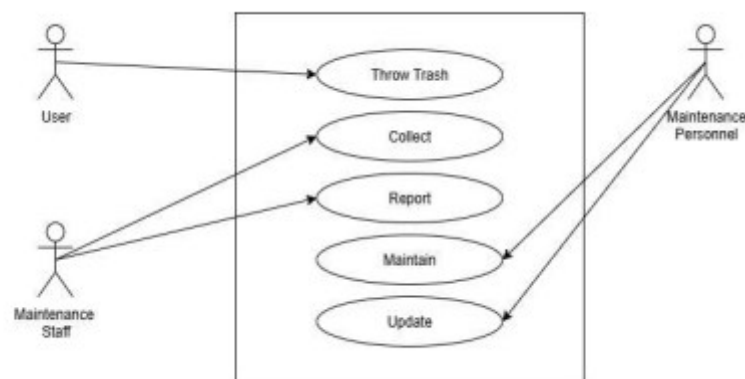
**Figure 5. Architectural Design**

Figure 5 shows a smart waste segregation system powered by Arduino Uno R3 and various sensors. At the heart of the system is the Arduino board, which serves as the main controller responsible for processing signals and coordinating all hardware components. Several sensors are connected to it: the ultrasonic sensor detects the presence of objects, while inductive and capacitive sensors identify the material type—metal, plastic, or biodegradable waste. These readings are displayed on the I2C LCD display, allowing users to monitor the system’s activity in real time. When an object is detected, the IR sensor and material sensors send signals to the Arduino, which then activates two servo motors responsible for moving sorting flaps or bins to direct the waste into the correct container. A buzzer provides audio feedback, signaling that the system is operating or has completed sorting. LED indicators light up to show which type of material is being processed: metal, plastic, or bio. A breadboard and resistors help manage connections and regulate current flow, while a 14.8V power supply ensures the components have enough energy to function. Overall, this setup integrates sensing, control, and actuation to automate the waste segregation process efficiently.



**Figure 6. Entity Relationship Diagram (Chen Model)**

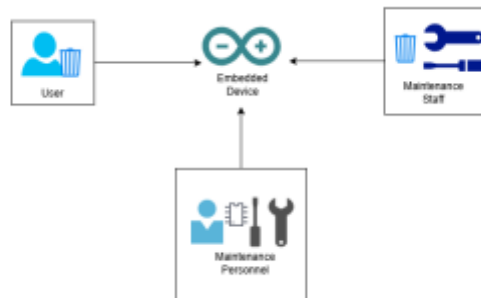
Figure 6 shows the process of an automated waste segregation system for LGUs. The process starts when the user throws waste into the system, which is then received and processed by the embedded device for automatic segregation. The maintenance staff collects the segregated waste from the device, while the maintenance personnel are responsible for maintaining and updating the system to ensure proper operation. Additionally, reports are generated between maintenance staff and personnel to monitor system performance and address issues.



**Figure 7. Use Case Diagram**

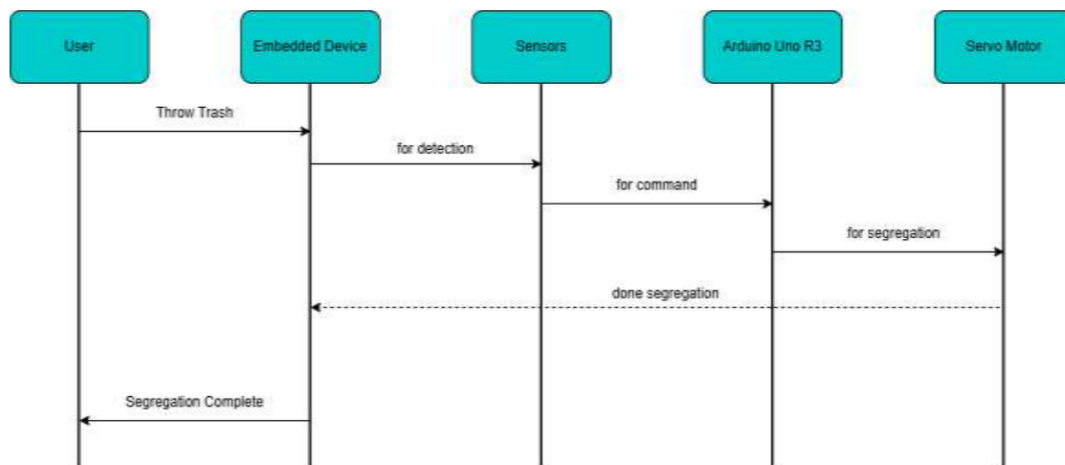
Figure 7 illustrates the interaction between the user, embedded device, and maintenance personnel within an Embedded system. The process begins when the “user” initiates an action, labeled as “Throw,” which represents disposing of waste into the system. This action is handled by the “embedded device”, which is responsible for detecting and processing the input. The device then performs a “Collect” function, where it gathers data or waste

information and communicates it to the “maintenance staff”. Meanwhile, the “maintenance personnel” are tasked with “Maintain and Update” operations, ensuring that the system remains functional and up to date. Finally, a “Report” process connects maintenance personnel and maintenance staff, allowing them to document system performance, issues, or collected data, ensuring proper monitoring and continuous improvement of the system.



**Figure 8. Deployment Diagram**

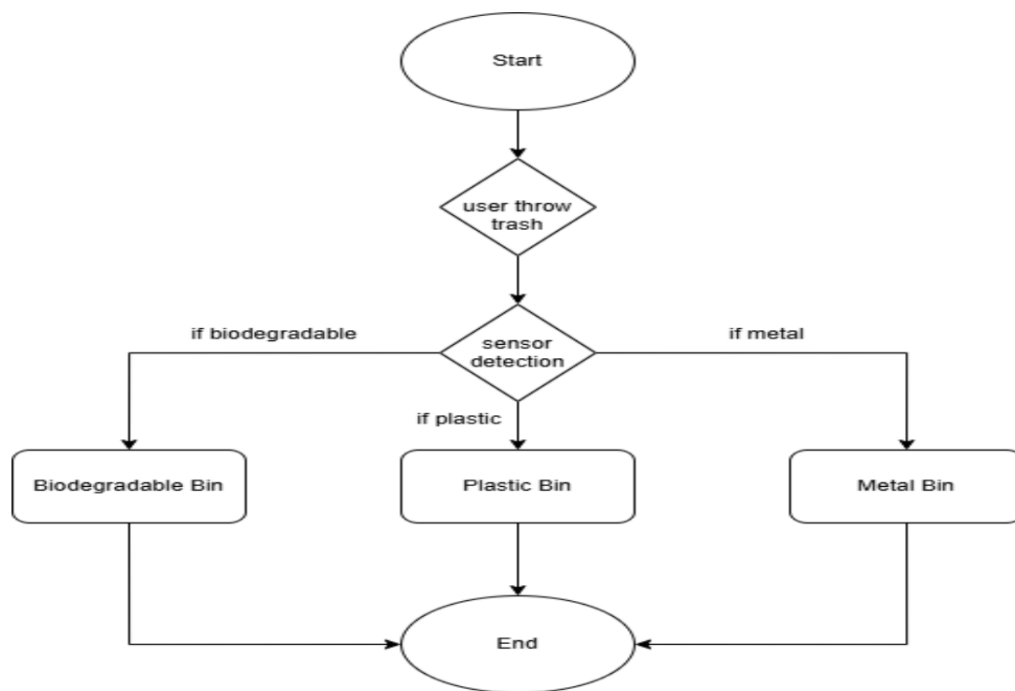
Figure 8 illustrates the interaction between the User and the Embedded Device in the development of an automatic LGU-based solid waste segregation prototype. In the diagram, the user represents individuals who place their waste into the smart bin system. When the user disposes of trash, the embedded device detects and processes the waste using sensors connected to the Arduino microcontroller. The Embedded device then performs automatic waste segregation by identifying the type of waste and directing it to the correct compartment. This process happens in real time without manual sorting. The arrow between the user and the embedded device shows how the user directly interacts with the system by inserting waste into the smart bin. Overall, the diagram explains that the user provides input to the embedded device, and the device performs the automated segregation process. It highlights the simple but important connection between human users and smart waste management technology.



**Figure 9. Sequence Diagram**

Figure 9 shows the step-by-step interaction between the User, Embedded System, Sensors, Arduino UnoR3, and Servo Motor in the automatic LGU-based solid waste segregation prototype. The process begins when the user

throws trash into the smart bin. This action triggers the embedded system to activate the sensors for waste detection. The sensors analyze the waste type and send the detected information to the Arduino Uno R3. The Arduino then processes the data and sends commands to the servo motor to move the waste into the correct compartment for proper segregation. After the sorting process is completed, the system sends a signal back indicating that segregation is done. Finally, the embedded system notifies the user that the segregation process is complete. This diagram explains the flow of communication and actions between each component, showing how the system automatically sorts waste with minimal user effort.



**Figure 10. Activity Diagram**

Figure 10 shows the step-by-step process of how the automatic waste segregation prototype works. The process begins at the Start point when the user throws trash into the smart waste bin. After the trash is inserted, the system activates its sensors to detect the type of waste. During the sensor detection stage, the system checks whether the waste is biodegradable, plastic, or metal. If the waste is biodegradable, it is directed to the biodegradable bin. If the waste is plastic, it is sent to the plastic bin, and if it is metal, it goes to the metal bin. The sorting process is done automatically by the Arduino-controlled mechanism. After the waste is placed into the correct compartment, the process ends. This activity diagram explains how the system receives input from the user, analyzes the waste using sensors, and performs automatic segregation into proper bins. It shows the flow of actions from start to finish in the smart waste management system.

### RESULTS

The evaluation of the Automatic LGU-Based Solid Waste Segregation Prototype Using Arduino was conducted with 15 respondents from Blancia College Foundation, Inc. Respondents included students, and staff who assessed the prototype using a structured questionnaire composed of sixteen items. The questionnaire was divided into four sections: Prototype Functionality (Q1–Q5), Reliability and Performance (Q6–Q9), Usability (Q10– Q13), and Overall Evaluation (Q14–Q16). Each item was rated on a five-point Likert scale, ranging from Strongly Agree (5) to Strongly Disagree (1).

Statement	Mean	Interpretation
1. Detects different types of waste using sensors.	5.00	Very High Effectiveness
2. Automatically segregates waste into correct bin.	5.00	Very High Effectiveness
3. Processes detection accurately via Arduino.	5.00	Very High Effectiveness

4. Sends waste status updates to monitoring device.	4.93	High Effectiveness
5. Works properly within the institution waste management setup.	4.87	High Effectiveness
Overall Weighted Mean	4.96	Very High Effectiveness

**Table 1. Prototype Functionality**

The frequency distribution table above shows how respondents rated the 31 prototype's functionality. For Q1 to Q3, all 15 respondents selected Strongly Agree, resulting in perfect mean scores of 5.00 and weighted totals of 75. This indicates unanimous confidence in the prototype's ability to detect, segregate, and process waste accurately. For Q4, 13 respondents rated Strongly Agree while 2 rated Agree. This produced a mean of 4.93, interpreted as High Effectiveness, suggesting that while most users were fully satisfied with the status update feature, few saw room for improvement. Similarly, Q5 received 12 Strongly Agree and 3 Agree responses, yielding a mean of 4.87 and interpreted as High Effectiveness. This shows that the prototype works well within the Institutions waste management setup, though some respondents felt integration could be refined further. Overall, the data confirms that the prototype's core functions detection, segregation, and processing were rated Very Highly Effective, while communication and Institution integration were still rated positively but with slight variation. This transparency in frequency counts strengthens the credibility of the evaluation and demonstrates that the system is both technically sound and practically applicable.

Statement	Mean	Interpretation
1. Operates consistently without malfunctioning.	4.93	High Effectiveness
2. Segregation mechanism responds properly after detection.	5.00	Very High Effectiveness
3. Sensors provide accurate readings during operation.	4.93	High Effectiveness
4. Performs well during continuous use.	4.87	High Effectiveness
Overall Weighted Mean	4.93	Very High Effectiveness

**Table 2. Prototype Reliability and Performance**

Respondents consistently rated the prototype's reliability and performance highly. Most selected Strongly Agree, confirming that the system operates without malfunction, responds properly, and maintains accurate sensor readings. A few respondents chose Agree, which slightly lowered the mean scores for Q6, Q8, and Q9, but the overall interpretation remains Very High Effectiveness, proving the prototype is dependable and sustainable under repeated operations.

Statement	Mean	Interpretation
1. Easy to use for students and staff.	5.00	Very High Effectiveness
2. Indicator lights or displays are easy to understand.	5.00	Very High Effectiveness
3. Instructions for using the prototype are clear	5.00	Very High Effectiveness
4. Helps reduce manual waste segregation work.	5.00	Very High Effectiveness
Overall Weighted Mean	5.00	Very High Effectiveness

**Table 3. Prototype Usability**

All respondents unanimously rated Strongly Agree for usability indicators. This produced perfect mean scores of 5.00 across Q10–Q13. The results confirm that the prototype is user-friendly, easy to understand, and practical, significantly reducing manual workload and making waste segregation more efficient for both students and staff.

**DISCUSSION**

# IJETRM

**International Journal of Engineering Technology Research & Management (IJETRM)**

**Journal Article**

<https://ijetrm.com/issue/>

This study aimed to design, develop, and evaluate an Automatic LGU-Based Solid Waste Segregation Prototype using Arduino to address the limitations of manual waste segregation within Blancia College Foundation, Incorporated. Guided by a developmental research design, the researchers constructed a working prototype integrating inductive, capacitive, and ultrasonic sensors with an Arduino Uno microcontroller and servo-driven sorting mechanisms.

The evaluation of the Automatic LGU-Based Solid Waste Segregation Prototype Using Arduino showed that the system performed exceptionally well across all dimensions. Respondents strongly agreed that the prototype is functional, reliable, and user-friendly, with a consolidated grand mean of 4.97, interpreted as Very High Effectiveness. This indicates that the system not only achieved its intended objectives but also demonstrated strong potential for institutional and community-level implementation. The findings highlight that the prototype aligns with the principles of Republic Act No. 9003, which emphasizes ecological solid waste management and the responsibility of local government units to adopt sustainable practices. Furthermore, the system's design and evaluation reflect adherence to internationally recognized standards such as the ISO 9001 Quality Management System, ensuring that its processes are consistent, reliable, and geared toward continuous improvement. Taken together, these results confirm that the prototype is technically sound, practically applicable, and compliant with both national legislation and global standards, making it a strong candidate for adoption in LGU waste management programs.

## ACKNOWLEDGEMENT

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## CONCLUSION

Based on the results of the evaluation, the Automatic LGU-Based Solid Waste Segregation Prototype Using Arduino was found to be very highly effective, with a consolidated grand mean of 4.97. Respondents strongly agreed that the system is functional, reliable, and user-friendly, and that it meets its intended objectives. The findings confirm that the prototype not only achieved its technical goals but also demonstrated strong potential for institutional and community-level implementation. The study further shows that the prototype aligns with the principles of Republic Act No. 9003, which mandates ecological solid waste management and emphasizes the responsibility of local government units to adopt sustainable practices. By automating waste segregation, the system supports compliance with this law and strengthens community participation in environmental protection. In addition, the prototype reflects adherence to internationally recognized standards such as ISO 9001 Quality Management System, ensuring that its processes are consistent, reliable, and geared toward continuous improvement. Therefore, the prototype is not only technically sound but also legally and globally aligned, making it a strong candidate for adoption in LGU waste management programs.

The researchers recommend that future improvements should focus on Local government units should consider adopting the prototype as part of their waste management initiatives to comply with Republic Act No. 9003 and enhance ecological practices in their communities. Future development of the system should continue to align with ISO 9001 and related environmental management standards (such as ISO 14001), ensuring quality, sustainability, and continuous improvement. Training programs should be conducted for students, staff, and community members to maximize usability and encourage active participation in automated waste segregation. Minor improvements may be made in communication and integration features to further strengthen the prototype's compatibility with LGU systems and ensure seamless monitoring. The system can be scaled up for larger communities or institutions, with additional features such as mobile app integration, real-time monitoring, and reporting dashboards to enhance transparency and accountability.

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