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# WIRELESS INTERNET-CONNECTED INCENTIVE SYSTEM FOR COLLECTING PLASTIC BOTTLES

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## Abstract

The study embarked on a comprehensive exploration of the design, testing, and evaluation of a system geared towards effectively managing the accumulation of plastic bottles while encouraging active engagement. Through meticulous examination, it was discovered that a system incorporating key features such as an intuitive user interface, wireless internet-connected incentives, and plastic bottle segregation mechanisms proved to be remarkably successful in tackling this environmental challenge. This finding underscores the importance of integrating innovative technological solutions to address pressing environmental issues and promote sustainable practices.

The study recommended further enhancements to the system to maximize its impact and reach. Specifically, it suggested integrating a plastic bottle segregation system with free internet access for learners, facilitated through Wi-Fi connectivity and an incentive-based reward system. By leveraging these additional features, the system could not only encourage plastic bottle segregation but also enhance accessibility for students, thus fostering a more inclusive and participatory approach to environmental stewardship. This recommendation highlights the potential synergies between technology, education, and environmental conservation efforts in promoting sustainable behaviors.

The evaluation of the system using ISO 25010 standards yielded encouraging results, with a weighted mean of 4.06 indicating that the system exceeded expectations significantly. This positive assessment underscores the effectiveness and reliability of the system in addressing the identified problem. It also underscores the importance of adhering to industry standards and conducting rigorous evaluations to ensure the quality and effectiveness of technological solutions aimed at addressing societal challenges.

In conclusion, the study not only shed light on the effectiveness of the developed system in managing plastic bottle accumulation but also provided valuable insights for future research endeavors. By leveraging the system's capabilities, future researchers can further enhance plastic bottle segregation efforts, promote student accessibility, and ensure the continued success of environmental conservation initiatives. Additionally, regular evaluations should be conducted to maintain optimal system performance and user satisfaction, thus ensuring the long-term sustainability of the implemented solution.

**Key words**: Environmental conservation, Environmental impact, Incentive system, Internet-connected, Plastic Bottle Collection, Plastic bottles, Recycling, Sustainability, Waste management, Wireless System.

## Introduction

Wi-Fi has emerged as a pivotal enabler of IoT (Internet of Things) innovation on a global scale, facilitating seamless connectivity among an estimated 19.5 billion Wi-Fi devices worldwide. This transformative technology has transcended traditional boundaries, permeating various sectors such as smart homes, smart cities, automotive, healthcare, enterprise, government, and industrial IoT environments. With Wi-Fi, users can automate their smart homes, monitor industrial supply chains in real-time, and enhance productivity across diverse work scenarios. The integration and interoperability offered by Wi-Fi pave the way for secure interconnections among IoT solutions, fostering unprecedented value creation in IoT applications and environments. (Dilixiati et al., 2023)

In the Philippines, the management of solid waste, particularly plastic bottles, remains a pressing concern. Despite legislative measures like Republic Act (RA) 9003, which prohibits open-burning of solid waste including plastic bottles, efficient waste management continues to pose significant challenges, especially in urban areas. The accumulation of waste not only poses environmental hazards but also jeopardizes public health due to the spread of diseases and pollution. The projected waste volume for the province of Sorsogon in 2024 underscores the urgent need for comprehensive waste management strategies to address this escalating issue. (Dilixiati et al., 2023)

Within Sorsogon province, the current waste management infrastructure faces limitations, with only a handful of biowaste shredders, composters, and recycling machines available across municipalities. As the volume of waste continues to rise, local authorities in Sorsogon must reevaluate their waste management programs to effectively tackle this growing challenge. It is imperative to develop innovative solutions tailored to the local context to improve waste segregation and management practices.

Against this backdrop, the proposed study titled "Wireless Internet-Connected Incentive System for Gathering Plastic Bottles" emerges as a potential solution to address the pressing issue of garbage segregation and management. By leveraging Wi-Fi technology, the study aims not only to incentivize individuals to participate in recycling initiatives but also to empower communities, including schools, to actively engage in waste segregation efforts. Moreover, the integration of an internet-connected incentive system holds promise in enhancing access to online resources, particularly in areas with limited connectivity, thereby promoting educational opportunities and community engagement. Through such initiatives, the study endeavors to contribute towards the realization of a more sustainable and resilient waste management ecosystem in Sorsogon province and beyond.

## General Objective

The primary aim of this project was to achieve the following specific objectives: To conceive and construct a Wireless Internet-Connected Incentive System for Collecting Plastic Bottles suitable for implementation at Aemilianum College Inc. This system was intended to manage the collection and retrieval of plastic bottles, thereby contributing to the institution and the wider community while generating Environmental and Social Impact. Noteworthy features of the system were accessible to students, teaching staff, and non-teaching workers of Aemilianum College Inc.

## Specific Objectives

This study aimed to:

1. Design and develop a system to manage the accumulation of plastic bottles by:
    - 1.1 Creating an intuitive user interface for efficient bottle collection.
    - 1.2 Implementing a wireless internet-connected incentive mechanism to encourage participation.
    - 1.3 Integrating a plastic bottle segregation system for effective waste management.
2. Provide free Internet Access to learners and implement a plastic bottle segregation system by:
    - 2.1 Establishing Wi-Fi connectivity accessible to students.
    - 2.2 Developing an incentive-based reward system to promote plastic bottle segregation.
    - 2.3 Implementing a user-friendly interface for easy access and participation.
3. Evaluate the proposed system by assessing software quality using the ISO 25010 evaluation instrument according to industry standards, focusing on:
    - 3.1 Functional Suitability
    - 3.2 Performance Efficiency
    - 3.3 Compatibility
    - 3.4 Usability
    - 3.5 Reliability
    - 3.6 Security
    - 3.7 Maintainability
    - 3.8 Portability

## Scope and Delimitations

This study focused on developing a Wireless Internet-Connected Incentive System for Collecting Plastic Bottles suited for implementation at Aemilianum College Inc.. The proposed system aimed to provide internet access to students within

the area where the system was deployed, accepting only clean, transparent plastic bottles up to 8.5cm in diameter. The plastic bottles were categorized into three sizes: small (ranging from 14cm to 27cm in length), medium (27cm), and large (33cm). Each size corresponded to different points, which were then converted into time duration; a small bottle earned 1 point, equivalent to a 15-minute time duration; a medium plastic bottle earned 2 points, equivalent to a 30-minute time duration; while large bottles earned 3 points, translating to a 45-minute duration. The proposed system incorporated two storage compartments for valid and invalid inputs and operated on a one-at-a-time process for inserting plastic bottles.

The geographical and environmental conditions, such as weather and the quality of the network service provider where the system was placed, were not considered in this study. The plastic allocation of the system was delimited, and due to the absence of a digital PIN in Arduino, the detection of nearly full storage was delimited. Furthermore, the proposed system could not identify whether a plastic bottle had been halved.

The system underwent evaluation by ten (10) IT professionals, ten and (10) students or beneficiaries.

**Significance of the Study**

Since Aemilianum College Inc. is the intended user of the proposed system, according to the researcher, the following will benefit from and be in support of the study:

**Students.** They can participate in the incentive program and earn rewards for collecting plastic bottles, which can be financially and environmentally beneficial.

**Faculty and Staff.** They can engage with the system to encourage and educate students about sustainability and environmental conservation.

**Aemilianum College Administration**. The system can help the college demonstrate its commitment to environmental responsibility and sustainability—local Community. Members of the local community around Aemilianum College can benefit from a cleaner environment due to reduced plastic waste.

**Environmental Clubs and Organizations.** The system can be a valuable tool for these groups to promote their missions and engage with the college community. Sponsors and Partners. Local businesses and organizations that support the college's environmental initiatives can gain positive exposure and goodwill through their involvement in the system.

**Maintenance and Janitorial Staff.** With fewer plastic bottles littering the campus, the workload for cleaning and maintenance staff may be reduced.

**Educational Programs.** Aemilianum College can integrate the system into its educational programs, offering students real-world experience in sustainability and technology.

**Researchers.** The data and information collected through the system can provide valuable insights for research

projects and studies related to waste management and sustainability.

## Gap Bridged by the Study

The developed system, "Wireless Internet-Connected Incentive System for Gathering Plastic Bottles," aimed to address a significant gap in sustainable waste management practices, specifically focusing on the collection of plastic bottles. At the time, many existing waste management systems lacked the capability for real-time data collection and failed to incorporate effective incentive mechanisms to encourage community participation actively. While some initiatives existed to promote recycling, there remained a notable gap in the development of innovative, technology-driven systems that integrated wireless connectivity, data processing, and incentives to manage plastic bottle collection efficiently. This study endeavored to bridge this crucial gap by designing and implementing a state-of-the-art system that not only facilitated plastic bottle collection but also utilized wireless internet connectivity to monitor, incentivize, and optimize the process. By doing so, this research contributed to the advancement of knowledge in smart and sustainable waste management solutions, with a specific emphasis on addressing the pressing environmental challenge posed by plastic waste accumulation in various regions.

## Conceptual Framework

The input of the conceptual framework outlined a comprehensive plan to manage the accumulation of plastic bottles and provide free internet access to learners while implementing a plastic bottle segregation system. It entailed designing and developing a system with an intuitive user interface for efficient bottle collection, integrating a wireless internet-connected incentive mechanism to encourage participation, and implementing a plastic bottle segregation system for effective waste management. Additionally, it emphasized the establishment of Wi-Fi connectivity accessible to students, the development of an incentive-based reward system to promote plastic bottle segregation, and the implementation of a user-friendly interface for easy access and participation. Furthermore, it highlighted the importance of evaluating the proposed system's software quality using the ISO 25010 evaluation instrument, focusing on various aspects such as functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. This comprehensive approach ensured the development of a robust system that addressed both waste management challenges and educational needs while adhering to industry standards for software quality assessment.

In the Process, involved the utilization of Rapid Application Development (RAD) methodology, which

facilitated a swift and iterative approach to system development. RAD emphasized rapid prototyping and feedback loops, allowing for the quick creation of functional prototypes and the incorporation of stakeholder input throughout the development cycle. This methodology enabled the research team to swiftly design and implement the wireless internet-connected incentive system for gathering plastic bottles, providing flexibility to adapt to changing requirements and refine the system iteratively. By leveraging RAD, the study ensured efficient progress, reduced development time, and increased stakeholder involvement, ultimately contributing to the timely delivery of a robust and user-friendly system tailored to address the challenges of plastic bottle accumulation and waste management.

The output of this study was the Wireless Internet-Connected Incentive System for Collecting Plastic Bottles, a sophisticated technological solution aimed at addressing the challenge of plastic bottle accumulation and promoting sustainable waste management practices. This system incorporated various components, including an intuitive user interface for efficient bottle collection, a wireless internet-connected incentive mechanism to encourage participation, and a plastic bottle segregation system for effective waste management. Through the implementation of this system, users could easily deposit plastic bottles into designated collection points, receive incentives via the internet-connected platform, and contribute to the reduction of plastic waste. The system's output represented a tangible solution to environmental concerns, leveraging technology to incentivize positive behavior change and foster community engagement in waste management efforts.

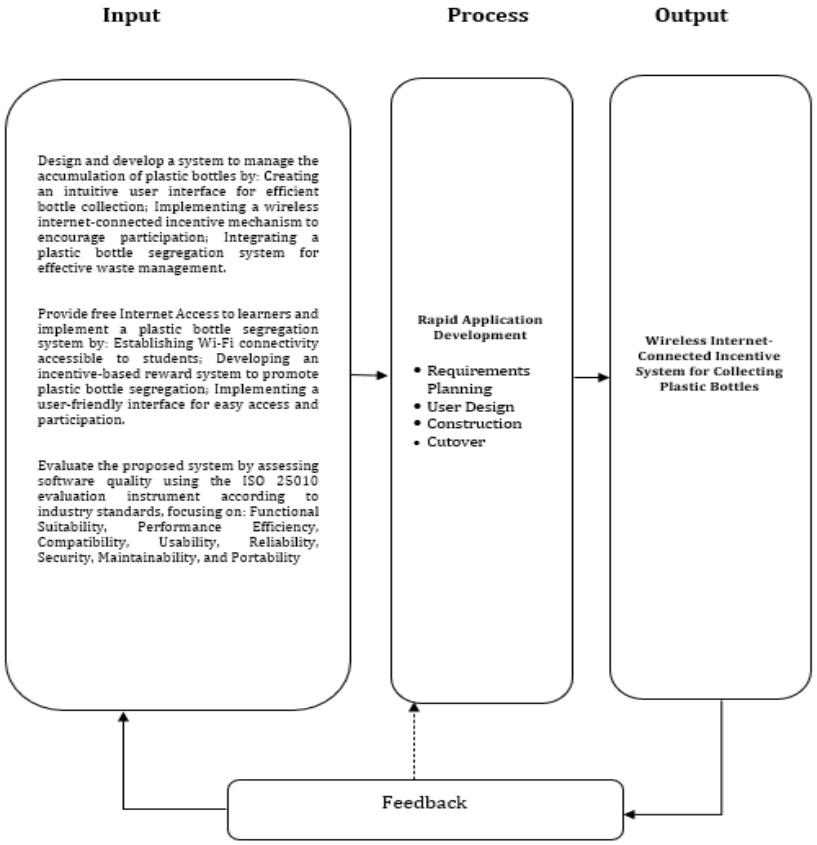

**Figure 1 – Conceptual Paradigm**

## Resources

Hardware and software requirements are included for the development of the proposed title, "Wireless Internet-Connected Incentive System for Gathering Plastic Bottles." below is the list of the hardware and software requirements.

**Table 3.1**

**Software and Hardware Requirements**

| Hardware | Software |
|---|---|
| Orange Pi PC | Arduino IDE 2.2.1 |
| Arduino Uno R3 | WiFi ng Bayan |
| IR Break Beam Sensor | |
| 24x2 LCD | |
| Jumper Wire | |
| Power Adapter | |
| WiFi Router/Modem | |
| Ultrasonic Sensor | |
| Load Cell | |
| Servo | |
| SD card | |
| Printed Circuit Board | |
| 2-PIN Terminal Block | |

Table 3.1 outlines the software and hardware requirements necessary for the implementation of the proposed system, the Wireless Internet-Connected Incentive System for Collecting Plastic Bottles. Hardware components include the Orange Pi PC, Arduino Uno R3, IR Break Beam Sensor, 24x2 LCD, Jumper Wire, Power Adapter, WiFi Router/Modem, Ultrasonic Sensor, Load Cell, Servo, SD card, Printed Circuit Board, and 2-PIN Terminal Block. These hardware components are essential for the system's functionality, enabling tasks such as data collection, user interaction, and wireless connectivity. On the software side, the system requires the Arduino IDE 2.2.1 for programming the Arduino Uno R3 and WiFi ng Bayan for managing wireless internet connectivity. Together, these hardware and software components form the backbone of the system, providing the necessary infrastructure to support its operation and functionality.

## Construction

The construction phase involved refining the prototypes developed in the previous phase and utilizing powerful automated tools to transform processes and data models into the final operational product. This phase also entailed ongoing prototyping and feedback [illegible] product that most suitably [illegible]

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requirements was developed. The significance of this third phase lay in the continued involvement of the client, who retained the ability to provide input at various stages. They had the opportunity to propose adjustments, modifications, or [illegible]eas to address emerging

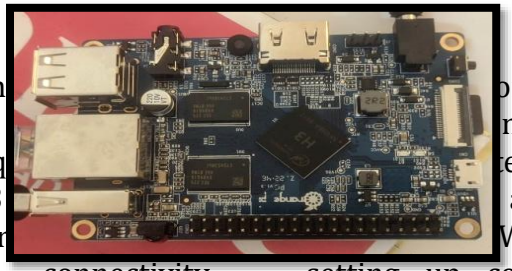

Figure 4.3 depicts th[illegible]ons like home automation an affordable single-board [illegible]nters. It supports multiple comes equipped with a q[illegible]tems, including Ubuntu and Cortex-A7 processor, 1GB [illegible] an Orange Pi PC alongside storage via a microSD car[illegible] WiFi distribution involved offers various flexible connectivity options, such as USB ports, Ethernet, HDMI, audio, and GPIO pins. Due to its cost-effectiveness and compact form factor, it has been widely utilized for do-it-yourself projects, educational purposes, setting up communication, developing software, and testing the connection. The process included connecting them using suitable hardware, developing WiFi distribution logic, and deploying the system once everything worked reliably.

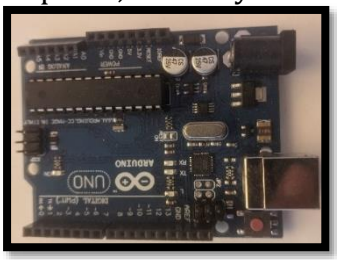

**Figure 4.4 Arduino Uno R3**

Figure 4.4 illustrates the Arduino Uno R3, a widely utilized microcontroller board in the field of electronics projects and prototyping. This device incorporates the ATmega328P microcontroller, which provided both digital and analog input/output pins, as well as multiple communication interfaces such as USB,

UART, SPI, and I2C. The Arduino Uno boasts a simple and uncomplicated design, making it easily accessible for beginners. Additionally, it benefits from a substantial community of creators and programmers. The Arduino IDE facilitated the programming of the device, making it a viable option for various applications, ranging from basic LED flashing projects to intricate embedded systems and robotics.

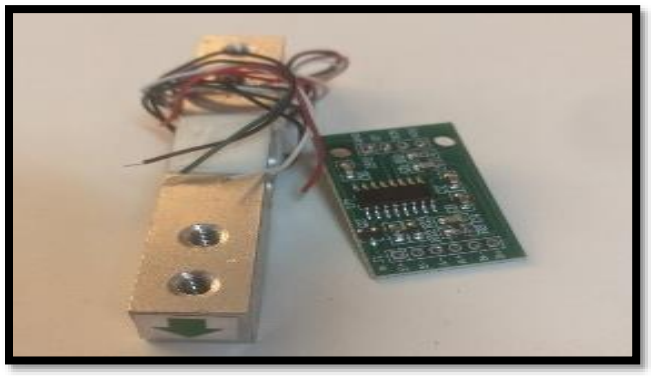

**Figure 4.5 Load Cell & HX711 Amplifier**

Figure 4.5 depicted the Load Cell and HX711 Amplifier, which were frequently used together in weight measurement applications. A load cell served as a transducer, converting the applied force or weight into an electrical signal. Conversely, the HX711 acted as an amplifier specifically designed to connect with load cells. Together, they provided precise and accurate weight measurements in various tasks, including scales and applications that detected force. The HX711 amplifier typically established communication with microcontrollers such as Arduino, enabling the integration of weight-sensing functionalities into electronic projects

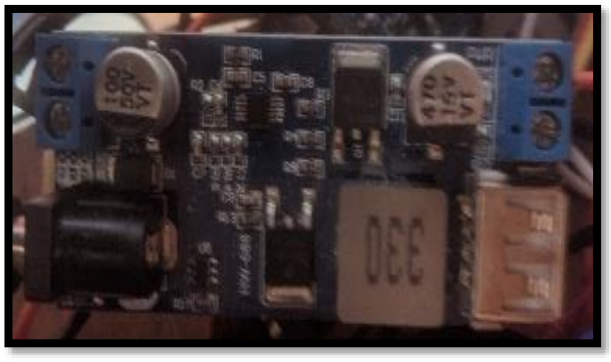


**Figure 4.6 HW-688**

Figure 4.6 depicted the HW-688 module, a DC-DC step-down converter specifically designed to convert either a 24V or 12V input into a 5V USB output. Users would connect their high-voltage source to the input, then utilize the USB output to power devices such as mobile phones. It was essential to verify the

polarity and, if necessary, adjust the voltage to 5 volts. Secure connections should be established, and safety requirements adhered to for proper utilization. For comprehensive instructions, users were advised to consult the manufacturer's literature or directly contact them.

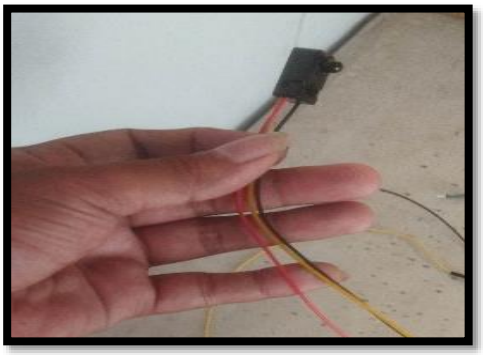

**Figure 4.7 IR Break Beam**

Figure 4.7 depicted the IR Break Beam sensor, comprising an infrared emitter and detector. The system detected the disruption of an infrared beam between the two components, triggering an event when the beam was obstructed. These sensors were highly regarded for their simplicity and durability in non-contact detection applications, leading to their widespread use in security systems and automation.

**Figure 4.8 Servo 996R**

Figure 4.8 showcased the servo motor, an essential component in robotics and automation, providing precise manipulation of angular or linear positioning through feedback systems. Servo motors were chosen for their precision and rapid response to input signals, rendering them popular in diverse applications such as steering mechanisms and robotic arms.

**Figure 4.9 - 24x2 LCD**

Figure 4.9 depicts the 24x2 LCD component, which was a display featuring 24 characters in each of its two rows. Widely employed in Arduino projects, it established communication with the microcontroller to exhibit information and proved highly adaptable for displaying both textual and numerical data. Integration involved the process of connecting and programming, leveraging the Arduino IDE libraries for communication.

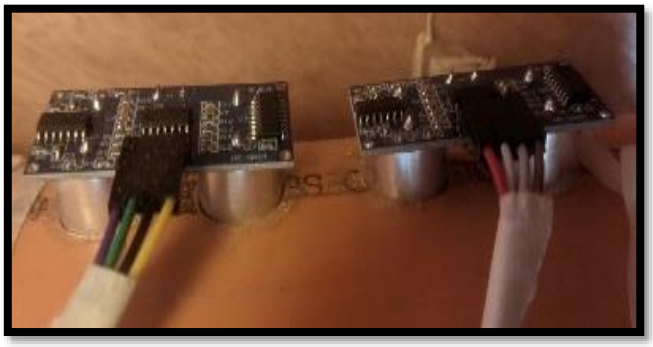

**Figure 4.10 Ultrasonic Distance Sensor - HC-SR04**

Figure 4.10 depicted the Ultrasonic Distance Sensor HC-SR04, which was a popular module for Arduino projects, using ultrasonic waves to measure distances. It was commonly utilized for proximity sensing and obstacle detection, calculating distances by sending and receiving ultrasonic pulses.

**Figure 4.11 AWG Jumper Wire**

Figure 4.11 showcased the AWG jumper wire, which was a frequently utilized wire type in Arduino projects. It was measured according to the American Wire Gauge standard, with thicknesses designed for specific uses. These wires were commonly utilized as male-to-male or female-to-female connectors to link components on breadboards or Arduino boards without soldering, thus making prototyping and circuit building more convenient.

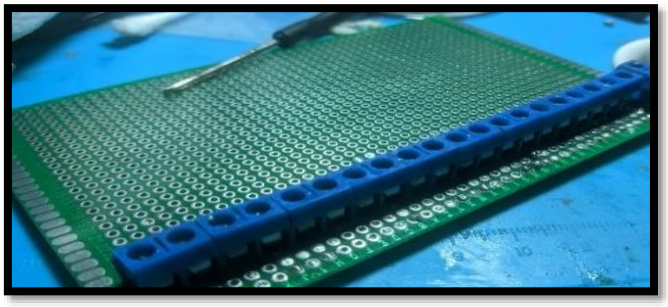

**Figure 4.12 PCB & 2 Terminal Block**

Figure 4.12 depicted the PCB boards and terminal blocks, which were frequently utilized in Arduino projects. PCB boards were used for installing electrical components, whereas terminal blocks functioned as connections for wiring. They were crucial for establishing circuits and linking different modules in Arduino-based systems.

**Figure 4.13 Wireless Internet-Connected Incentive System for Gathering Plastic Bottles**

Figure 4.13 depicted the developed Wireless Internet-Connected Incentive System for Gathering Plastic Bottles.

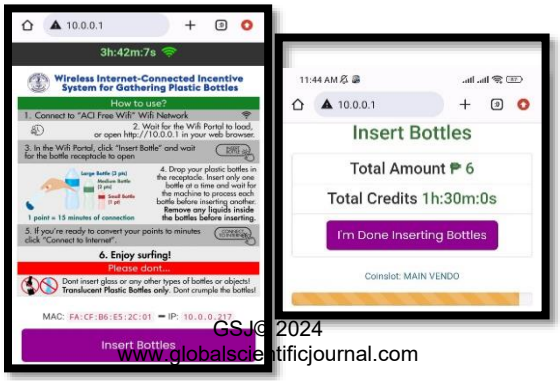

**Figure 4.14 Device Portal**

Figure 4.14 depicted that when the device was connected to the machine's WiFi, the portal automatically opened, the insert bottles button was used to open the entrance of the machine, and when the plastic bottle insertion was completed and ready to connect to the internet, the Done inserting bottles button was tapped.

**Table 4. 11**

**Overall Evaluation of the Developed System**

| Sub-Characteristic | IT Experts | Students/Beneficiaries | Weighted Mean | Interpretation |
|---|---|---|---|---|
| Functional Suitability | 4.14 | 4.28 | 4.21 | More than what is expected |
| Performance Efficiency | 4.57 | 4.71 | 4.08 | More than what is expected |
| Compatibility | 3.85 | 4.0 | 3.92 | More than what is expected |
| Usability | 4.43 | 4.75 | 4.59 | More than what is expected |
| Reliability | 4.02 | 4.20 | 4.11 | More than what is expected |
| Security | 4.14 | 4.24 | 4.19 | More than what is expected |
| Maintainability | 4.30 | 4.30 | 4.30 | More than what is expected |
| Portability | 4.00 | 4.12 | 4.06 | More than what is expected |
| Average | 4.00 | 4.12 | 4.06 | More than what is expected |
| General Average | **4.06** | | | More than what is expected |

Table 4.11 presents the Overall Evaluation of the Developed System across various characteristics as assessed by both IT Experts and Students/Beneficiaries, along with the weighted mean and interpretation. The evaluation encompasses Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability, and Portability. Each characteristic received ratings indicating that they exceed expectations, as reflected in the weighted mean. Notably, Usability received the highest weighted mean, indicating a particularly strong performance in this aspect, emphasizing

the system's ease of use and effectiveness in meeting user needs. The Overall Average also suggests that the system's performance across all evaluated characteristics surpasses expectations, highlighting its robustness and effectiveness in addressing the requirements and objectives of the study. This comprehensive evaluation underscores the success of the developed system in meeting user expectations and industry standards, positioning it as a highly functional, efficient, and reliable solution for its intended purposes.

## Summary of Findings

After the system was designed, tested, and evaluated, the following findings were established:

1. Indicate that designing and developing a system with an intuitive user interface, a wireless internet-connected incentive mechanism, and a plastic bottle segregation system effectively manages the accumulation of plastic bottles while encouraging active participation.
2. Implementing a plastic bottle segregation system alongside free internet access for learners through establishing Wi-Fi connectivity, developing an incentive-based reward system, and implementing a user-friendly interface is recommended to effectively promote plastic bottle segregation and enhance accessibility for students.
3. The evaluation of the proposed system was conducted using the ISO 25010 evaluation instrument, adhering to industry standards, and focusing on functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability, resulting in a weighted mean of 4.06, indicating that the developed system exceeded expectations significantly.

## Conclusions

The study's findings lead to the formulation of the following conclusions:

1. That a system has an intuitive user interface, a wireless internet-connected incentive mechanism, and a plastic bottle segregation system to effectively manage the accumulation of plastic bottles while encouraging active participation.

2. Providing free internet access to learners and implementing a plastic bottle segregation system through establishing Wi-Fi connectivity, developing an incentive-based reward system, and implementing a user-friendly interface effectively promoted plastic bottle segregation and enhanced accessibility for students.

3. The evaluation of the proposed system was conducted using the ISO 25010 evaluation instrument, adhering to industry standards, and focusing on functional suitability,

performance efficiency, compatibility, usability, reliability, security, maintainability, and portability, resulting in a weighted mean of 4.06, indicating that the developed system exceeded expectations significantly.

## Recommendations

The researcher would want to advise upcoming researchers to enhance the system by:

1. The school can purposefully utilize it to manage the accumulation of plastic bottles and promote active participation, leveraging its intuitive user interface, wireless internet-connected incentive mechanism, and plastic bottle segregation system.

2. To further encourage plastic bottle segregation and improve student accessibility, continuing to provide free internet access while enhancing the existing plastic bottle segregation system through measures such as refining Wi-Fi connectivity, incentivizing participation, and ensuring a user-friendly interface is recommended.

3. To maintain the high standard of performance and functionality exhibited by the developed system, regular evaluations using industry-standard methodologies should be conducted to ensure continuous improvement and adherence to user requirements.

## References

**A. Books**

Gupta, B. M., & Agrawal, D. P. (Eds.). (2020). Internet of Things (IoT): Technologies, Applications, Challenges and Solutions. Springer.

Pogge, T., Rimmer, M., & Rubenstein, K. (Eds.). (2010). Incentives for Global Public Health: Patent Law and Access to Essential Medicines. Cambridge University Press.

Reisch, L. A., & Thøgersen, J. (Eds.). (2015). Waste Management and Sustainable Consumption: Reflections on Consumer Waste. Springer.

Stallings, W. (2005). Wireless Communications and Networking. Pearson Education.

Unhelkar, B. (2009). Green IT: Technologies and Applications. CRC Press.

**B. Journals**

Chen, Y., & Zhang, Y. (2018). Design and Implementation of a Wireless Sensor Network for Waste Collection Management. IEEE Transactions on Industrial Informatics, 14(5), 2173-2181. https://doi.org/10.1109/TII.2017.2786060

Lee, C. S., & Han, S. H. (2019). Wireless Internet-Connected Systems for Waste Management: A Review. Waste Management, 94, 1-15. https://doi.org/10.1016/j.wasman.2019.05.016

Smith, J. D., & Johnson, A. B. (2020). Enhancing Recycling Behavior Through Incentives: A Review of Empirical Evidence. Journal of Environmental Psychology, 72, 101520. https://doi.org/10.1016/j.jenvp.2020.101520

Wang, X., Tan, L., & Xu, L. (2017). A Study on Incentive Mechanism of Recycling Reverse Logistics Based on Internet of Things. Journal of Cleaner Production, 142, 1347-1357. https://doi.org/10.1016/j.jclepro.2016.07.013

Zhang, Y., & Chen, Y. (2016). A Survey on Waste Management System Based on Internet of Things. Journal of Sensor and Actuator Networks, 5(2), 10. https://doi.org/10.3390/jsan5020010

**C. Internet Access**

Abrantes M. R. (2023), The Effect of Rewards on Student Achievement. Retrieved September 5, 2023, from Pressreader.com website: https://www.pressreader.com/philippines/sunstar-pampanga/20160925/281599534970826

Adones., P. (2021, October 31). Setting Up Serial Coinslot Sensor using Arduino - AdoPiSoft Blog. Retrieved September 20, 2023, from AdoPiSoft Blog - WiFi Hotspot News, Guides, and Tutorials website: https://blog.adopisoft.com/article/setting-up-serial-coinslot-sensor54

AdoPiSoft. (2021, October 29). How To Assemble AdoPiSoft Hotspot Machine DIY Kit - AdoPiSoft Blog. Retrieved September 20, 2023, from AdoPiSoft Blog - WiFi Hotspot News, Guides, and Tutorials website: https://blog.adopisoft.com/article/how-to-assemble-ado-piso-wifi-diy-kit55

Affum M.Q(2022). THE EFFECT THE EFFECT OF IN T OF INTERNET ON STUDEN T ON STUDENTS STUDIES Retrieved August 18, 2023, from eric.ed.gov website: https://files.eric.ed.gov/fulltext/EJ1353463.pdf 16

Allanigue A. (2022, August 25). Parañaque program provides incentives to recycling. Retrieved September 5, 2023, from PIA website: https://pia.gov.ph/news/2022/08/25/paranaque-program-provides-incentives-to-recycling#:~:text=Through%20the%20Eco%2DIkot%20Center,other%20sustainable%20or%20reusable%20items.33

Amponsah, K. D., Aboagye, G. K., Narh-Kert, M., Commey-Mintah, P., & Boateng, F. K. (2022, June 30). The Impact of Internet Usage on Students' Success in Selected Senior High Schools in Cape Coast Metropolis, Ghana.17

Anne, H., Arapoc, J. A., & Valientes, R. M. (2017, May 2). An Experimental Investigation on Performance Under Individual, Team, and Mix Incentive Schemes. Retrieved September 5, 2023, from Ssrn.com website: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=299647427

Antoniette, A., Culaba, A. B., & Dadios, E. P. (2019). Internet of Things in the Philippines: A Review. https://doi.org/10.1109/hnicem48295.2019.907288222

Antonio L.C, Study on Recyclables Collection Trends and Best Practices in the Philippines. Retrieved September 2, 2023, from eria.org website: https://www.eria.org/uploads/media/Research-Project-Report/RPR_FY2009_10_Chapter_3.pdf24

Arquero, E. V. (2021). Arduino-based water consumption monitoring system with SMS notification. Retrieved from https://www.cosmosjournal.in/wp-content/uploads/2021/06/CET-JJ21-Emilverchristian-V.-Arquero.pdf 49

Atienza V.(2011), Review of the Waste Management System in the Philippines: Initiatives to Promote Waste Segregation and Recycling through Good Governance. Retrieved September 1, 2023, from nswai.org website: https://www.nswai.org/docs/Review%20of%20the%20Waste%20Management%20System%20in%20the%20Philippines.pdf19

Bin-e | Smart Waste Bin. (2023). Retrieved September 8, 2023, from Bine. world website: https://bine.world/36

Bona, J. N. R., Ombao, I. P. V., & Vidola, R. J. R. (2022). Bottle to Loot Exchange and Automatic Waste Segregator (BAWaS). BS Electronics Engineering. https://www.adnu.edu.ph/cse/2022/07/28/students-research-seniors-project/47

Booc, R. P., Rafaela, K. B., II, L. C. J., Cortuna, I. J. M., Gabiana, B. M., Sagun, L. J. B. D., & Asuncion, J. E. (2020). IoT based: mobile controlled appliances with online monitoring system. ISJ Theoretical & Applied Science, 08 (88), 58-64.

Britton, J. (2021). What Is ISO 25010?; What Is ISO 25010? | Perforce; https://www.perforce.com/

Chien, C. (2020, February 4). What is Rapid Application Development (RAD)? Retrieved September 24, 2023, from Codebots website: https://codebots.com/app-development/what-is-rapid-application-development-rad#:~:text=in%20business%20globally.-,Rapid%20application%20development%20(RAD)%20is%20a%20methodology%20that%20focuses%20on,frequent%20iterations%20and%20continuous%20feedback.

Darell, J., Aguda, C., Ramona, M., Alcantara, A., Bueser, J., & Balinado, J. (2019). Design and Implementation of Water Velocity Monitoring System Based on Hydropower Generation and Antonyan Vardan Transform (AVT) Statistics. Journal of Engineering and Computer Studies, 4(2). Retrieved from https://lpulaguna.edu.ph/wp-content/uploads/2019/10/5.-Design-and-Implementation-of-Water-Velocity-Monitoring-System-Based-on-Hydropower-Generation-and-Antonyan-Vardan-Transform-AVT-Statistics.pdf50

DepEd ORDER No. 5, s. 2014, Implementing Guidelines on the Gulayan sa Paaralan, Solid Waste Management, and tree planting under the National Greening Program (NGP), Retrieved September 21, 2023, from deped.gov.ph website: https://www.deped.gov.ph/wp-content/uploads/2014/02/DO_s2014_05.pdf25

Dilinazi Dilixiati, Suzuki, S., Yoshida, H., & Takahashi, F. (2023). A case study of unwillingness toward PET bottle recycling behaviors - a new contingent valuation approach that requests only a simple comparison of perceptive stimuli. https://doi.org/10.1016/j.resconrec.2022.106746 2

Drepaul N. A., Sustainable Cities and the Internet of Things (IOT) Technology IOT technology improves the development of smart cities' infrastructures and reduces over-population stresses on JSTOR. (2020). Retrieved August 15, 2023, from Jstor.org website: https://www.jstor.org/stable/26924960?searchText=arduino+uno&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Darduino%2Buno&ab_segments=0%2Fbasic_search_gsv2%2Fcontrol&refreqid=fastly-default%3Aea08c1ce6911f0b730d9eadd0204d6a9&seq=28

Endaya, et al (2020); Design and Implementation of Automated Waste Segregator with Smart Compression

Geron, E. K., Parayno, A. S., Resurreccion, K., Talisic, P. A., Zaide, A. L., Agustin, E., ... & Beaño, M. G. (2022, November). Carbon Reducing Plastic Incinerator using Cold Plasma Pyrolysis: A Hybrid Machine. In TENCON 2022-2022 IEEE Region 10 Conference (TENCON) (pp. 1-5). IEEE.

Ghulamullah Maitlo, Ali, I., Hubdar Ali Maitlo, Ali, S., Imran Nazir Unar, Muhammad Bilal Ahmad, … Muhammad Naveed Afridi. (2022). Plastic Waste Recycling, Applications, and Future Prospects for a Sustainable Environment. Sustainability, 14(18), 11637–11637. https://doi.org/10.3390/su14181163711

Globe (2018), The Internet of Things: What Philippine Manufacturers Need to Know. Retrieved September 5, 2023, from my business academy.ph website: https://mybusinessacademy.ph/wcontent/uploads/2018/05/The-Internet-of-Things.pdf28

Haitaamar, Z. N., & Shata, A. (2022, October). Design of a Smart IoT-AI Enabled Recycling Machine with Gamification Techniques. In 2022 Workshop on Microwave Theory and Techniques in Wireless Communications (MTTW) (pp. 155-159). IEEE.

Harris G. L., The Raspberry Pi Primer on JSTOR. (2018). Retrieved August 15, 2023, from Jstor.org website: https://www.jstor.org/stable/26305581?read-now=1#page_scan_tab_contents6

Internet of Things | Wi-Fi Alliance. (2022). Retrieved November 30, 2023, from Wi-fi.org website: https://www.wi-fi.org/discover-wi-fi/internet-things 1

Internet Use in the Classroom: Potential and Pitfalls for Student Learning and Teacher-Student Relationships on JSTOR. (2023). Retrieved August 18, 2023, from Jstor.org website: https://www.jstor.org/stable/44428684?searchText=free%20internet%20for%20student&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Dfree%2Binternet%2Bfor%2Bstudent&ab_segments=0%2Fbasic_search_gsv2%2Fcontrol&refreqid=fastly-default%3A587a5164974b3c0cad8334bdeae0d3b515

IoT-based Smart Waste Management System using Arduino. (2023, February 2). Retrieved September 8, 2023, from Pantech.AI website: https://www.pantechsolutions.net/iot-based-smart-waste-management-system-for-smart-city38

Ismail, N. S., Rashid, N. A., Zakaria, N. A., Khan, Z. I., & Mahmud, A. R. (2020, July 1). Low-Cost Extended Wireless Network Using Raspberry Pi 3B+. https://doi.org/10.1109/ISIEA49364.2020.918821546

J. Nikhila. (2017). Web-based Environmental Monitoring System using Raspberry Pi. https://doi.org/10.1109/ctceec.2017.845496445

Jaokar A., Using Raspberry Pi to Teach Computing "Inside Out" on JSTOR. (2013). Retrieved September 20, 2023, from Jstor.org website: https://www.jstor.org/stable/44430133?read-now=1&seq=2#page_scan_tab_contents5

Karunarathna, A., Rajapaksha, T., Gamagedara, Y., Kaldera, S., & Vidanage, N. (2020,). Effective Plastic Waste Management in Sri Lanka. Retrieved August 18, 2023, from Jstor.org website: https://www.jstor.org/stable/resrep2901213

Kato, G. A., Yamongan, J. S., Manao, J. M. N., Arcega, R. A. A., Espino, R. L. E., Capili, R. D., & Magsumbol, J. A. V. (2022, October). Emerging Technologies in the Philippines: Internet of Things (IoT). In International Conference on Intelligent Computing & Optimization (pp. 300-308). Cham: Springer International Publishing.

Kesuma, M. E. K., Kesuma, G. C., & Taher, A. (2024). Internet of Things to realize Education in Industry 4.0 based on Sustainability Environment. In E3S Web of Conferences (Vol. 482, p. 05008). EDP Sciences.

Khan, I. H., & Javaid, M. (2022). Role of Internet of Things (IoT) in adoption of Industry 4.0. Journal of Industrial Integration and Management, 7(04), 515-533.

Kowasch, M. (2022). Circular Economy, Cradle to Cradle and Zero Waste Frameworks in Teacher Education for Sustainability. International Journal of Sustainability in Higher Education, 23(6), 1404–1425. Retrieved from https://eric.ed.gov/?id=EJ134643312

Landram, C. (2022). Plastic Bottles In Architecture: A How To Guide On Life-Cycle Through Reuse.

larcon, J. C. A., Ocsina, C. J. R., & Castro, E. G. (2020). An indoor air quality monitoring system using Arduino Uno is used in Cainta, Rizal, and Pasay City, Philippines. Retrieved from https://proceedings.spp-online.org/article/view/SPP-2020-2D-0352

Learn, (2024). Performance Efficiency design principles - Microsoft Azure Well-Architected Framework | Microsoft Learn

Lourens, M., Tamizhselvi, A., Goswami, B., Alanya-Beltran, J., Aarif, M., & Gangodkar, D. (2022, December). Database management difficulties in the internet of things. In 2022 5th International Conference on Contemporary Computing and Informatics (IC3I) (pp. 322-326). IEEE.

Mohamed Ismail S, Gohul Raj R, R Dhamodharan, & Sekar, G. (2021). Smart Obstacle Recognition System using Raspberry Pi. https://doi.org/10.1109/iccmc51019.2021.941841044

N.A (2017), Philippines Solid Waste at a Glance. Retrieved September 1, 2023, from senate.gov.ph/publication website: https://www.senate.gov.ph/publications/SEPO/AAG_Philippine%20Solid%20Wastes_Nov2017.pdf20

Nestor Michael Tiglao, PhD. 3 Most Promising IoT Use Cases for the Philippines. (2021). Retrieved September 5, 2023, from Linkedin.com website: https://www.linkedin.com/pulse/3-most-promising-iot-use-cases-philippines-nestor-michael-tiglao-phd29

Nolasco, E., Henrique, P., Pereira Gonçalves, Júlia, Cristina, M., Monteiro, & Nascimento. (2021). Characterization of Solid Wastes as a Tool to Implement Waste Management Strategies in a University Campus. International Journal of Sustainability in Higher Education, 22(2), 217–236. Retrieved from https://eric.ed.gov/?q=internet+of+things+plastic+waste+management&id=EJ128127510

Orange Pi - Orangepi. (2024). Retrieved December 1, 2023, from Orangepi.org website: http://www.orangepi.org/html/hardWare/computerAndMicrocontrollers/service-and-support/Orange-Pi-PC.html 18

Pacis D.M.M, Subido E. DC., Bugtai N.T(2017). Research on the Application of Internet of Things (IoT) Technology Towards A Green Manufacturing Industry. Retrieved September 2, 2023, from dlsu.edu.ph website: https://www.dlsu.edu.ph/wp-content/uploads/pdf/conferences/research-congress-proceedings/2017/SEE/SEE-II-024.pdf23

Paculanan, R. S., & Carino, I. (2019). LPG Leakage Detector using Arduino with SMS Alert and Sound Alarm. Retrieved from https://www.ijitee.org/wp-content/uploads/papers/v8i6c2/F10420486C219.pdf51

Paul, J., Endaya, S., Mabitasan, F., Cyvel, J., & Gonzales, M. (2020). Design and Implementation of Automated Waste Segregator with Smart Compression. Journal of Engineering and Computer Studies, 4(3). Retrieved from https://lpulaguna.edu.ph/wp-content/uploads/2022/01/6.-Endaya-Mabitasan-Gonzales-Waste-Segregator.pdf53

Prof. Samantha Cardoso, Pereira, R. G., Naik, D. A., Naik, S. S., & Naik, S. D. (2016). Capacitive Sensor Interfaced with Arduino. International Journal for Science Technology and Engineering, 2(9), 90–95. Retrieved from https://ijste.org/Article.php?manuscript=IJSTEV2I90397

Rahardhita Widyatra Sudibyo, Nobuo Funabiki, Minoru Kuribayashi, Kwenga Ismael Munene, Md. Manowarul Islam, & Kao, W.-C. (2019). A TCP Fairness Control Method for Two-Host Concurrent Communications in Elastic WLAN System Using Raspberry Pi Access-Point. https://doi.org/10.1109/iccet.2019.872690740

Ramdoo. I., (2019)KEY EMERGING TECHNOLOGY TRENDS from NEW TECH, NEW DEAL: Technology Impacts Review on JSTOR. (2023). Retrieved August 18, 2023, from Jstor.org website: https://www.jstor.org/stable/resrep21976.5?searchText=IOT+WASTE+management&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3DIOT%2BWASTE%2Bmanagement%26so%3Drel&ab_segments=0%2Fbasic_search_gsv2%2Fcontrol&refreqid=fastly-default%3A6211642d3992799f382ed400f6345ab0&seq=214

Rapid Application Development (RAD) | Definition, Steps & Full Guide. (2022, January 23). Retrieved September 24, 2023, from Kissflow.com website: https://kissflow.com/application-development/rad/rapid-application-development/

Republic Act No. 9003 | GOVPH. (2001, January 26). Retrieved November 23, 2023, from Official Gazette of the Republic of the Philippines website: https://www.officialgazette.gov.ph/2001/01/26/republic-act-no-9003-s-2001/ 3

Republic Act No. 9512, AN ACT TO PROMOTE ENVIRONMENTAL AWARENESS THROUGH ENVIRONMENTAL EDUCATION AND FOR OTHER PURPOSES

Respposposa. C., Arduino Uno. Project. (2019). Retrieved September 13, 2023, from Scribd website: https://www.scribd.com/document/608037306/Arduino-Uno-Project 48

Retrieved September 5, 2023, from Official Gazette of the Republic of the Philippines website: https://www.officialgazette.gov.ph/2008/12/12/republic-act-no-9512/30

Rosnani Binti Affandi. (2023, July 4). Development of the Metal and Non-Metal Waste Sorting System Design by using an Arduino UNO. Retrieved September 5, 2023, from ResearchGate website: https://www.researchgate.net/publication/372066606_Development_of_the_Metal_and_Non-Metal_Waste_Sorting_System_Design_by_using_an_Arduino_UNO34

Saifudaullah Bin Bahrudin, Rosni Abu Kassim, & Norlida Buniyamin. (2013). Development of Fire alarm system using Raspberry Pi and Arduino Uno. https://doi.org/10.1109/iceese.2013.689504041

Schuch, D., Lederer, J., Fellner, J., & Scharff, C. (2023). Separate collection rates for plastic packaging in Austria–A regional analysis taking collection systems and urbanization into account. Waste Management, 155, 211-219.

Singh, R., Gaur, N., & Shikha Bathla. (2020). IoT-based Air Pollution Monitoring Device using Raspberry Pi and Cloud Computing. 2020 4th International Conference on Electronics, Communication and Aerospace Technology (ICECA). https://doi.org/10.1109/iceca49313.2020.929764842

Siwakorn Jindarat, & Pongpisitt Wuttidittachotti. (2015). Smart farm monitoring using Raspberry Pi and Arduino. https://doi.org/10.1109/i4ct.2015.721958243

Solid Waste \Management Division -. (2023, October 31). Retrieved November 23, 2023, from Solid Waste Management Division - website: https://nswmc.emb.gov.ph/ 4

Stannard, L. (2021, October 15). 8 Innovative Smart Waste Management Technologies. Retrieved September 5, 2023, from Bigrentz.com website: https://www.bigrentz.com/blog/smart-waste-management35

Syed Tasnim Ahmed. (2018, November 26). Arduino Project Report - Academic Project. Retrieved September 8, 2023, from ResearchGate website: https://www.researchgate.net/publication/342425973_Arduino_Project_Report_-_Academic_Project39

TESDA, Value Creation and Job Generation "The potential of the solid waste management" (2023). Retrieved September 5, 2023, from tesda.gov.ph website: https://tesda.gov.ph/Uploads/File/LMIR/2023/23.03.06_LMI%20on%20SWM.pdf31

THE Impact OF Providing FREE Internet Connection FOR ICT Students. (2015). Retrieved September 1, 2023, from Studocu website: https://www.studocu.com/ph/document/university-of-batangas/mechanical-engineering/the-impact-of-providing-free-internet-connection-for-ict-students/6928967021

Vergel de Dios, M. Ericsson, PLDT, and Smart connect for environmental conservation in the Philippines in partnership with DENR and Sasmuan LGU. (2022, January 25). Retrieved September 5, 2023, from ericsson.com website: https://www.ericsson.com/en/press-releases/2/2022/1/ericsson-pldt-and-smart-connect-for-environmental-conservation-in-the-philippines32

Verizon (2023), Wifi; What is Wi-Fi? | Definition, Meaning & Explanation | Articles | Verizon

Vijay, S., Pilla Nitish Kumar, Raju, S., & Vivekanandan, S. (2019). Smart Waste Management System using ARDUINO. International Journal of Engineering Research & Technology, 8(11). https://doi.org/10.17577/IJERTV8IS11000437

Zanella, A., Bui, N., Angelo Paolo Castellani, & Zorzi, M. (2012). Internet of Things for Smart Cities. Retrieved August 15, 2023, from ResearchGate website: https://www.researchgate.net/publication/260540297_Internet_of_Things_for_Smart_Cities9



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