

Design and Development of a Plastic Bottle-Activated Fan Prototype

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ABSTRACT

This capstone project, titled "Design and Development of a Plastic Bottle-Activated Fan Prototype," addresses the growing global concern of non-biodegradable plastic waste by integrating discarded materials into a functional electrical system. The study aimed to design a prototype that utilizes plastic bottles as a triggering mechanism to activate a battery-powered fan, evaluating the system's effectiveness and its potential to promote environmental awareness. Using a descriptive-developmental research design, the researchers constructed a model where the insertion of a plastic bottle is acting similarly to a coin-operated mechanism which completes a circuit to power a small DC fan. Testing was conducted at Mindanao State University – Maigo College of Education, Science, and Technology (MSU-MCEST) to measure response time, consistency, and power stability using electrical measurements and observation checklists. Results indicated that the triggering system effectively activated the fan, with the battery providing sufficient and stable power for operation. Participant feedback through a Likert scale evaluation suggested that the prototype serves as an effective educational tool, demonstrating practical waste utilization and the principles of basic automation. The study concludes that simple, low-cost trigger-based systems offer a viable and accessible approach to promoting sustainable waste management and environmental responsibility within a campus setting.

Keywords: Plastic Waste Management, Trigger-Based Activation, Waste Utilization, Battery-Powered System, Prototype Development

INTRODUCTION

The increasing problem of plastic waste and improper waste segregation continues to contribute to environmental issues such as flooding and drainage blockage in developing countries like the Philippines (Greenpeace Philippines, 2022; Jambeck et al., 2015). This situation highlights the need for practical, low-cost, and accessible solutions that promote environmental awareness and responsible waste management.

Several studies have emphasized the importance of circular economy approaches in addressing plastic pollution (Van Caneghem et al., 2019; Ritchie et al., 2023). However, many existing systems rely on industrial-scale processing such as waste-to-energy technologies, which require complex infrastructure and high operational costs (Brunner & Morf, 2025; MDPI Energies, 2024). As an alternative, this study focuses on a simplified “waste-as-trigger” mechanism that directly utilizes plastic bottles as a physical input for activating an electrical system (ScienceDirect Topics, 2024; IntechOpen, 2011).

The system follows a basic input-process-output structure commonly used in automation and control systems (Bolton, 2015; Universalium, 2024). When a plastic bottle is inserted into the prototype, it triggers a circuit that activates an electrical load for a controlled duration. The design is supported by fundamental principles of switches and relay-based control systems (Wikipedia, 2024; Hameed et al., 2021). The electrical system uses a battery-based power supply with inverter conversion to support alternating current operation (Goodwin, 2024; Comtar, 2024). Sensors and control elements are used to ensure proper activation and system reliability (Fraden, 2016; Eaton, 2024). Similar educational prototypes have shown that hands-on engineering models are effective in teaching basic electrical and sustainability concepts (Yilmaz et al., 2018; López et al., 2024).

This study aligns with Sustainable Development Goal 12, which promotes responsible consumption and production, by demonstrating how waste materials can be repurposed into functional educational systems (UNESCO, 2023; United Nations Environment Programme, 2023). Ultimately, the project bridges environmental awareness and basic automation through a low-cost and accessible design.

REVIEW OF RELATED LITERATURE

Synthesis

Plastic waste remains one of the most pressing environmental challenges globally, particularly in developing countries where waste management systems are limited (Greenpeace Philippines, 2022; Nature Sustainability, 2024). Studies show that recycling rates remain low, and much of the plastic waste ends up in landfills or natural environments (Society of Chemical Industry, 2025; Yaqoob et al., 2025). Circular economy approaches have been proposed as a sustainable solution, focusing on resource recovery and reuse rather than disposal (Van Caneghem et al., 2019; Brunner & Morf, 2025). However, most implementations remain large-scale and industrial in nature (MDPI Energies, 2024; Schiffer et al., 2015). This creates a gap for small-scale, educational, and community-based systems. In response, this study adopts a simplified automation model using a plastic bottle as a trigger mechanism for activating an electrical circuit. The system incorporates basic automation principles such as input-output control, relay switching, and timed operation (Bolton, 2015; Hameed et al., 2021; Eaton, 2024). It also demonstrates the application of embedded system concepts in a simplified form suitable for educational use (Lee & Seshia, 2017).

Previous studies have shown that small-scale engineering prototypes can improve understanding of electrical systems and sustainability concepts among students (Putra et al., 2020; García et al., 2024; Yilmaz et al., 2018). Therefore, this study fills the gap by presenting a low-cost and accessible system that combines waste utilization and basic automation in a practical learning tool.

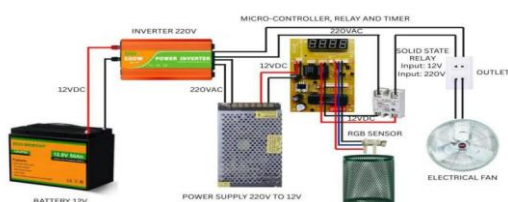
METHODOLOGY

This study employed a descriptive-developmental research design in the development and evaluation of a plastic bottle-activated fan prototype conducted at Mindanao State University – Maigo College of Education, Science and Technology (MSU-MCEST). The Plastic Bottle-Activated Fan Prototype was designed as a small-scale trigger-based electrical system that utilizes a 12V 32Ah battery as its primary power source. The system was developed to demonstrate how plastic bottles can be integrated into a functional electrical application while promoting environmental awareness and sustainable waste management practices.

The structure of the prototype was constructed using PVC pipes to provide a lightweight yet stable support frame for the electrical and mechanical components. The system consists of a battery, 200W power inverter, timer module, solid-state relay (SSR), triggering sensor mechanism, outlet panel, and electric fan. These components work together to regulate and distribute electrical power throughout the system.

The prototype was intended primarily for educational demonstration and small-scale environmental awareness campaigns within the campus setting. Although the system performed effectively during testing, the prototype was not designed for long-term industrial operation or large-scale waste-management implementation.

Figure 1 System Diagram of the Plastic Bottle-Activated Fan Prototype



The prototype is powered by a 12V 32Ah rechargeable DC battery connected to a 200W inverter that converts the current to 220V AC to drive a 35W–50W electric fan. During testing, the system maintained a stable voltage output with minimal fluctuations, while the solid-state relay and timer module effectively regulated the fan's activation and run duration to maximize energy efficiency. The assembly utilized insulated wiring, PVC structural supports, and secure mounting, resulting in zero instances of overheating, short circuits, or component failures during initial operation.

The system operates through a simple input-process-output mechanism. The input stage involves the insertion of a plastic bottle, which activates a triggering mechanism. The process stage involves signal handling through a control system that manages activation timing. The output stage delivers electrical power to the fan for a controlled duration using a relay-based switching system (Hameed et al., 2021; Eaton, 2024).

The electrical system is powered by a 12V 32Ah battery and supported by a 200W inverter to convert DC power to AC supply for the fan (Goodwin, 2024; Comtar, 2024). Proper insulation and wiring were applied to ensure safety during operation. Testing procedures included multimeter readings to monitor voltage stability and system performance (Fraden, 2016). In addition, a 5-point Likert scale was used to evaluate user feedback regarding the prototype's effectiveness and educational value (Yilmaz et al., 2018; López et al., 2024).

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary Of Findings

The evaluation of the plastic bottle-activated fan prototype demonstrated a highly reliable and operational system capable of delivering continuous 220V AC output through a 12V 32Ah storage battery and a 200W inverter setup. Respondents and researchers noted that the system functioned smoothly with minimal voltage fluctuations, confirming that the integrated 4-digit timer module successfully managed power distribution and regulated operation runtimes to maximize energy efficiency. While minor, manageable power interruptions occurred occasionally, they did not hinder overall system performance. Most notably, both students and faculty highly agreed that the physical model successfully demonstrated the concept of circular waste utilization. It effectively increased ecological awareness and promoted proper plastic handling within the Mindanao State University - Maigo College of Education Science and Technology (MSU-MCEST) campus, showcasing a direct link between technological automation and environmental responsibility.

Conclusion

Based on these findings, it is concluded that the plastic bottle-activated fan prototype is technically feasible, functionally viable, and highly reliable as an off-grid educational tool. The project successfully confirms that small-scale, everyday electrical appliances can be safely powered and controlled through a standalone, trigger-based input-process-output circuit layout. By utilizing ordinary plastic bottles to directly complete an operational circuit loop, the mechanism effectively bridges the gap between complex hardware automation and practical recycling. Ultimately, this low-cost, simplified engineering architecture provides an engaging, hands-on instructional model that proves sustainability and electronic automation can be combined into a cost-effective system to foster campus environmental stewardship.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are proposed:

1. **Improvement of the Triggering Mechanism:** Future designs should enhance the sensitivity and durability of the triggering system, such as using more reliable sensors or switches, to ensure consistent activation when plastic bottles are inserted.
2. **Use of Higher-Quality Components:** It is recommended to use higher-quality electrical components, such as pure sine wave inverters, to improve system performance, reduce power interruptions, and extend the lifespan of the device.

3. **Integration of Solar Charging System:** Future researchers are recommended to integrate a solar charging system to support the battery when it is low. This will help maintain continuous operation of the prototype, improve energy sustainability, and reduce dependency on external electrical charging sources.
4. **Expansion of System Capability:** Future studies may explore expanding the system to power additional low-energy devices to test its capacity, efficiency, and scalability.
5. **Structural and Material Enhancement:** The use of more durable and stable materials is recommended to improve the overall safety, stability, and longevity of the prototype, especially for long-term or public demonstrations. Incorporating robust, low-cost structural enclosures from small-scale design frameworks ensures the device withstands public school environments safely (Universidad Industrial de Santander, 2018).
6. **Educational Utilization:** The prototype may be utilized as an instructional tool in teaching basic electrical systems, automation, and environmental awareness in academic settings. Deploying interactive, small-scale experimental sets acts as an excellent mechanism for green technology education (Yilmaz et al., 2018).
7. **Comparative Analysis with Existing Systems:** Future studies should compare the prototype with existing recycling machines or smart waste-management systems to evaluate efficiency, cost-effectiveness, and operational advantages.
8. **Scalability Testing in Public Areas:** Future researchers may test the prototype in larger public or institutional settings such as schools, parks, terminals, or recycling stations to evaluate its practicality, effectiveness, and scalability in real-world applications.
9. **Detailed Technical Testing:** Future studies should include more detailed technical analysis such as circuit design evaluation, voltage regulation testing, power consumption measurement, load testing, and energy-efficiency analysis to further improve the reliability and performance of the prototype.
10. **Durability and Long-Term Performance Testing:** Extended testing is recommended to determine the durability, maintenance requirements, and long-term operational stability of the system under continuous use and different environmental conditions.
11. **Integration of Advanced Waste-Management Technologies:** Future developments may explore the integration of technologies such as pyrolysis systems, automated bottle counters, or smart monitoring systems to enhance waste utilization and increase the innovation value of the project.

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