IMPROVISED PORTABLE GRINDER FOR BIODEGRADABLE WASTE

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ABSTRACT

This study developed and evaluated an improvised portable grinder for biodegradable waste to address challenges in waste management, particularly in resource-limited areas. the device was designed to process biodegradable materials, such as food remnants and leaves, into compostable outputs for school gardens. by emphasizing portability, cost-effectiveness, and the use of recycles materials, the grinder offers a sustainable and practical alternative to high-cost, infrastructure-dependent waste management technologies.

The study employed a developmental survey research design, focusing on the device's fabrication, assembly, and testing processes. Its acceptability was evaluated based on functionality, mobility, durability, efficiency, and safety. Results showed high acceptability, with functionality and safety being particularly well-regarded. The grinder's mobility-enhancing pushcart design and user-friendly operation were found to meet the needs of schools in remote or resource-constrained settings. Recommendations include increasing feeder capacity, strengthening the grinding mechanism, and promoting renewable energy options to further enhance its usability and environmental sustainability. The study underscores the device's potential as a cost-effective solution for improving biodegradable waste management in schools.

Keyword: - *biodegaradable waste, improvised grinder, waste management, innovation*

1. INTRODUCTION

1.1 Biodegradable Waste Management

Effective waste management is essential for environmental sustainability and addressing challenges related to urbanization and climate change. Inadequate waste bins and unsecured storage often lead to scattered biodegradable waste, disrupting segregation efforts and organic recycling. This issue aligns with Sustainable Development Goals (SDGs) (11), (12), (13), and (15), which focus on sustainable cities, responsible consumption, climate action, and land management respectively.

In the Philippines, the Ecological Solid Waste Management Act of 2000 (RA 9003) provides a framework for waste reduction, recycling, and public engagement, aligning with global sustainability goals Atienza, 2020; Roa, 2024)[1]. Despite innovative solutions like waste-to-energy technologies, advanced recycling methods, and smart systems, challenges such as affordability, technological limitations, and public resistance hinder effective implementation (Rani & Yendluri, 2024). Strong policies, community involvement, and advanced technologies are essential for sustainable waste management (Roy et al., 2023).

A significant issue is the lack of secured waste bins in public spaces, neighborhoods, and commercial areas. Unsecured bins often spill, causing litter that clogs drainage systems, exacerbates flooding, and creates unsanitary conditions. During the monsoon season, scattered biodegradable waste decomposes rapidly, attracting pests and spreading diseases. These issues damage waste management efforts, particularly the collection and processing of biodegradable waste. Addressing these infrastructure gaps is crucial for achieving cleaner and healthier communities.

To address this issue, installing durable stands specifically designed for biodegradable waste bins is crucial. These stands can prevent bins from being displaced by weather, animals, or accidental contact, ensuring that organic waste remains contained and can be collected efficiently for composting or other eco-friendly processes. Local

government units (LGUs) can incorporate such infrastructure into their waste management strategies, alongside public education campaigns on the importance of proper waste segregation and bin security.

Encouraging community responsibility and fostering habits like proper disposal of biodegradable waste can significantly reduce litter and improve the efficiency of waste processing systems. These efforts not only enhance public health and the environment but also promote sustainable practices, contributing to cleaner, greener communities and supporting local tourism by preserving the visual appeal of public spaces.

1.2 Challenges in Biodegradable Disposals

Biodegradable waste disposal poses significant challenges, particularly in developing countries where infrastructure and resources are often insufficient. While innovations in solid waste management offer potential solutions, the persistent issues associated with handling organic waste remain largely unresolved. Organic waste, as the largest component of municipal solid waste, demands effective and sustainable disposal methods to prevent environmental and health problems.

Overflowing and unattended garbage bins are a major contributor to unsanitary conditions that foster the spread of diseases. Rajanthi, Rajamani, and Priya (2019)[2] highlighted how improper waste management, particularly of biodegradable materials, leads to serious public health risks. Their robotic trashcan innovation aimed to address these issues by automating waste collection and ensuring timely disposal. However, its reliance on advanced technology like sensors and Wi-Fi limits its applicability to well-equipped urban areas, leaving less developed regions—where biodegradable waste is often most mismanaged—struggling with the same challenges.

Mismanagement of organic waste, particularly food scraps and yard trimmings, creates additional challenges. Conant and Fadem (2024)[3] emphasized that composting is one of the most effective methods for handling biodegradable waste, but its adoption is limited by a lack of public awareness, space constraints, and insufficient community support. While composting can significantly reduce waste and improve soil health, implementing these practices on a larger scale remains difficult in areas where infrastructure and education on waste segregation are lacking.

In the Philippines, these challenges are particularly acute. Mantaring (2024) [4]noted that biodegradable waste comprises half of the country's daily waste output. Despite the relatively low per capita waste generation of 0.4 kilograms, the volume exceeds the capacity of the country's landfills, compounding existing waste management problems. Poor segregation practices and inadequate facilities for composting or recycling biodegradable materials exacerbate the issue, resulting in increased environmental degradation and public health risks.

Addressing the challenges of overflowing garbage bins requires more than technological innovations. It calls for comprehensive strategies that include improved infrastructure, public education on waste segregation, and community-based programs to promote composting and other sustainable practices. Without these measures, the mismanagement of biodegradable waste will continue to pose a significant obstacle to effective solid waste management.

1.3 Need for Innovative Solutions in Waste Management

The effective use of grinding-based treatments has emerged as a promising innovation in addressing waste management challenges, particularly in the detoxification and valorization of solid waste. According to He et al. (2022)[5], grinding techniques have shown significant potential in recovering valuable resources from metal-containing wastes such as spent lithium-ion batteries, waste printed circuit boards, and incineration ash. These methods align with the growing emphasis on resource recovery and sustainable waste processing, offering a practical approach to reduce environmental hazards while converting waste into reusable materials.

The increasing complexity of waste management calls for innovative practices that extend beyond traditional methods. Bathia (2019)[6] underscored the role of advanced technologies like gasification and pyrolysis in transforming non-recyclable waste into energy resources. However, the successful adoption of such innovations depends heavily on robust infrastructure and scientific research capabilities, which remain limited in many developing regions.

In the Philippines, Coracero et al. (2021)[7] highlighted the implementation of Republic Act 9003 as a significant step toward addressing waste issues. While this legislation encourages segregation and waste diversion, its impact has been inconsistent due to resource constraints and varying local government support. The introduction of

valorization strategies, such as grinding treatments, presents an opportunity to bridge these gaps by transforming waste into valuable resources, thereby strengthening the act's effectiveness.

Globally, the concept of integrated solid waste management (SWM) has gained traction as a comprehensive framework. However, its application in developing regions often neglects socio-economic and cultural nuances (Marshall & Farahbakhsh, 2019)[8]. Advanced grinding and crushing technologies offer scalable solutions that can complement SWM principles by addressing the specific needs of these regions, fostering both environmental and economic benefits.

Innovations like grinding and crushing technologies, alongside traditional methods such as composting and anaerobic digestion, highlight the need for a multi-faceted approach to waste management. By focusing on resource recovery and sustainable practices, these methods provide viable pathways to mitigate environmental challenges and contribute to a circular economy. However, to maximize their potential, supportive policies, public awareness, and localized implementation strategies must be prioritized.

1.4 Environmental Benefits of Grinding Biodegradable Wastes

Poor waste management practices, including inadequate collection systems and improper disposal methods, significantly contribute to environmental problems such as air pollution, water contamination, and soil degradation. Open and unsanitary landfills are major sources of these issues, contaminating drinking water, spreading diseases, and emitting harmful greenhouse gases. These challenges highlight the urgent need for practical and innovative waste management solutions to preserve and protect the environment.

The development of an improvised portable grinder for biodegradable wastes aims to address these critical environmental concerns. By grinding organic waste into smaller particles, the device facilitates faster decomposition, enhances composting efficiency, and reduces the volume of waste. This process not only minimizes the burden on landfills but also significantly decreases methane emissions—a potent greenhouse gas released during the decomposition of biodegradable waste in unmanaged landfills. Ground biodegradable materials can be transformed into nutrient-rich compost, improving soil quality and reducing the need for chemical fertilizers, which often contribute to water pollution.

Air, water, and soil pollution are interlinked issues that exacerbate ecosystem degradation and biodiversity loss. The World Health Organization (WHO, 2015)[9] identified poor waste management as a significant contributor to these problems, emphasizing the need for innovative methods to handle waste effectively. An improvised portable grinder provides a practical solution, accelerating waste decomposition rates, reducing odors, and limiting emissions that contribute to air pollution.

Globally, approximately 2.12 billion tons of municipal waste are generated annually, with this figure projected to rise by 70% by 2050 (The World Counts, 2024; Lama, 2024)[10]. While the growing waste problem poses a dire environmental threat, scalable methods like grinding biodegradable waste offer an optimistic avenue for mitigating waste-generated pollution. According to Lama (2024), "Unlike other complex climate-related challenges, scalable methods to curb waste-generated pollution and methane emissions already exist in practice." The improvised portable grinder aligns with this vision, presenting a cost-effective and scalable solution for mitigating the adverse effects of waste mismanagement.

In Southeast Asia, particularly in the Philippines, the waste management crisis is pronounced, with 14.66 million tons of waste produced annually (Jain, 2017). A substantial portion of this waste is biodegradable, yet improper disposal practices such as open dumping and burning remain prevalent due to inadequate infrastructure (Manas, 2023)[11]. These harmful practices release pollutants that degrade the environment and pose serious health risks. The improvised portable grinder provides a sustainable alternative, enabling communities to handle biodegradable waste more efficiently while reducing their reliance on harmful disposal methods.

Local initiatives in the Philippines, such as the "No Barangay Material Facility Recovery (MRF), No Collection" policy in Bulan, Sorsogon (Ochave, 2018)[12], illustrate the potential for community-level interventions in waste management. Integrating portable grinding technology into these initiatives could further enhance their effectiveness by streamlining waste segregation and composting processes. By making waste management more accessible and efficient, the improvised grinder empowers communities to adopt sustainable practices and promotes environmental stewardship.

Beyond addressing landfill dependency and greenhouse gas emissions, the improvised portable grinder supports circular economy principles. It transforms organic waste into valuable compost, restoring soil fertility, reducing erosion, and fostering sustainable agricultural practices. By leveraging local resources and user-friendly

design, the grinder bridges the gap between innovation and accessibility, providing a practical solution for communities with limited infrastructure.

The development of this improvised portable grinder underscores the importance of adopting innovative techniques to tackle waste management challenges. By offering tangible environmental benefits such as reduced pollution, enhanced soil quality, and decreased landfill reliance, the grinder presents a viable tool for sustainable waste management. With proper implementation and community involvement, this technology can play a transformative role in promoting cleaner and more sustainable environments, contributing meaningfully to global efforts to combat climate change.

1.5 **Improvised Portable Grinder for Biodegradable Waste**

The study by Purwaningrum, Purbasari, and Puspita Rini (2022)[13] introduced a grinder machine to address waste management challenges faced by pottery craftsmen in Mayong Lor Village, Jepara. Renowned for its pottery, roof tiles, and bricks, the village generates significant waste from defective products, which often accumulate and harm the environment. The grinder machine, powered by an 8hp diesel engine and utilizing a hammer mill system, efficiently processes waste into fine powder that can be reused in clay production. This innovation streamlines waste treatment, reduces environmental impact, and improves production efficiency, providing a sustainable solution for the local clay-based craft industry.

Similarly, the present study developed an improvised portable grinder for biodegradable waste, such as leaves and food remnants, to address ongoing waste disposal challenges. This grinder converts biodegradable waste into fertilizer for "gulayan sa paaralan" (school gardens), echoing the concept of sustainable waste treatment introduced in the earlier research. This innovation offers several practical features: (a) it can be assembled and disassembled anytime and anywhere, (b) it uses an electric motor to power the grinder, and (c) it is movable, thanks to its push-cart design, allowing it to be easily transported and moved.

The researcher was inspired to undertake this project due to his experiences at San Francisco National High School in Bulan, Sorsogon. Over his seven years of teaching there, he observed significant issues with garbage segregation and collection, particularly in managing biodegradable waste. In fact, daily waste accumulation in the school, consisting of student trash, fallen leaves, and leftover canteen food, has become a pressing concern. One of the resulting problems is the presence of stray cats and dogs drawn to the biodegradable food waste.

Additionally, garbage collection in the school is often delayed due to its challenging location atop a mountain. The muddy terrains and pathways further hinder timely waste collection. Considering these challenges, a review of the literature focused on trends in improving waste management, particularly for biodegradable waste, was undertaken. The studies discussed strategic plans for waste management, from collection and transportation to treatment, analysis, and disposal. Innovations through advanced technological developments were emphasized, although these typically involve high-end technologies.

Afolalu, et al. (2021)[14] highlighted that rapid urbanization, population growth, and evolving consumption patterns in developing countries have resulted in substantial amounts of waste. In response, they designed a smart dustbin to automate waste disposal, reducing the need for human intervention. This invention utilized a microcontroller-based Arduino board integrated with various sensors, making waste collection more efficient. However, while this invention is impressive, it is not yet applicable in non-highly urbanized areas, including parts of Manila, due to the high costs and potential job displacement.

Similarly, Ho Huh et al. (2021)[15], a group of Korean inventors, designed a smart trash bin for future smart cities. They identified issues with overuse of standard trash bags, leading to secondary pollution. To address this, they developed an IoT-based Smart Trash Separation Bin using sensors and image processing technology, significantly reducing labor and administrative costs. Nevertheless, this system is also limited to wealthier nations due to its high technological requirements.

On the other hand, Manikandan et al. (2019) and Jajoo et al. (2018)[16]focused on smart waste bins with integrated sensors for waste level detection, further advancing waste management through automation and communication technologies. Despite their effectiveness, these solutions are constrained by technological infrastructure needs, making them less feasible in regions with limited resources. In contrast, researchers like Gaddam et al. (2018) and Baihaqi et al. (2018)[17] emphasized using IoT and solar-powered technologies for waste management. Their innovations included real-time monitoring and mobile applications for efficient waste collection. Yet, these advancements are largely applicable only in cities with robust technological and energy infrastructures.

1.6 The Frameworks of the Study

Theoretical Framework. This study employs the theoretical framework designed based on the development of an improvised portable grinder for biodegradable wastes. This framework ensures a structured approach to identifying challenges, designing solutions, and evaluating the product's impact.

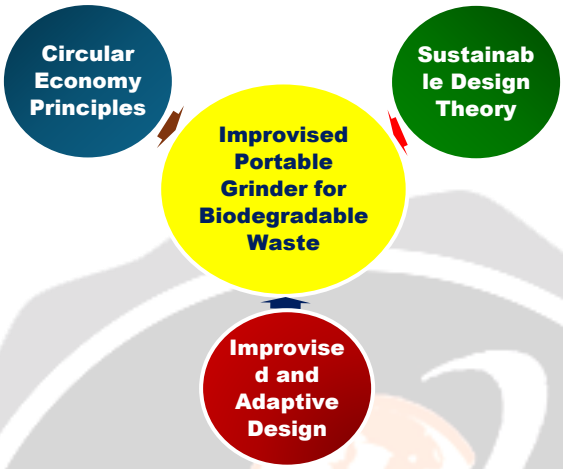

Fig -1: Theoretical Paradigm of the Study

The diagram revolves around the central concept of an Improvised Portable Grinder, which symbolizes an innovative, low-cost, and context-specific tool. This device is not just a product of necessity, but also a reflection of practical ingenuity shaped by real-world constraints. The bold arrows in the diagram indicate that this grinder is not developed in isolation—it is directly influenced by three foundational ideas: the Circular Economy Principle, Sustainable Design Theory, and Improvisation and Adaptive Design. Together, these concepts provide a strong framework for understanding how simple technologies can be made efficient, sustainable, and locally relevant.

The Circular Economy Principle presents a sustainable alternative to the traditional linear "take-make-dispose" economic model by promoting the continuous use of resources through practices such as reuse, repair, and recycling (Атамась & Бекмурзаева, 2023; Bugaian & Diaconu, 2020)[18]. It focuses on minimizing waste, maximizing resource efficiency, and addressing critical environmental issues like resource depletion and pollution (Bugaian & Diaconu, 2020)[19]. In the context of the improvised grinder, this principle can be applied by incorporating salvaged motors from broken appliances, scrap metal from construction sites, and discarded plastic components, thereby reducing production costs and environmental impact. Additionally, designing the grinder for easy disassembly allows for the repair, replacement, or recycling of parts, embodying the circular economy's emphasis on product durability and lifecycle extension (Атамась & Бекмурзаева, 2023).

Although the principles of "Reduce, Reuse, and Recycle" are increasingly recognized, societal readiness and systemic transformation remain challenges (Seicaru Bucata & Marcuta, 2024). The shift toward a circular economy necessitates innovative product design, responsible production practices, and the integration of technologies such as artificial intelligence and Industry 4.0 (Seicaru Bucata & Marcuta, 2024). Furthermore, it involves supportive business models and policy interventions aimed at achieving economic resilience, equitable resource distribution, and environmental sustainability, all while fostering a mindset that prioritizes long-term ecological well-being (Domenech & Stegemann, 2021; Атамась & Бекмурзаева, 2023).

The Sustainable Design Theory expands the concept of environmental responsibility by considering not only materials and waste but also the broader social and long-term impacts of a product on both people and the planet. It advocates for creating tools that fulfill human needs in a responsible, enduring manner, aligning well with the goals of sustainable development. Applied to the portable grinder, this could involve minimizing electricity consumption or enabling manual operation to suit off-grid communities, selecting non-toxic, eco-safe materials, and ensuring durability, safety, and consistent performance—especially in underserved or rural areas where reliable tools are

essential. Integrating these sustainability principles with Design for Manufacturing and Assembly (DFMA) further enhances environmental and production efficiency (Fatima et al., 2018)[20].

In the context of biomass grinders, sustainable design methodologies emphasize safety, energy efficiency, and eco-efficiency as key factors (Kruszelnicka et al., 2019)[21]. Additionally, the issue of tool wear is a significant sustainability consideration, influencing the economic, environmental, and social dimensions of grinding operations. While tool wear can compromise process stability and increase user costs, it paradoxically benefits manufacturers by driving replacement sales—underscoring the complex relationship between sustainability and product lifecycle (Linke, 2015). Altogether, these insights reinforce the importance of embedding sustainable thinking into both the design and manufacturing processes of grinding tools.

Improvisation and Adaptive Design emphasizes creativity, flexibility, and the capacity to modify tools and systems based on locally available resources and specific community needs. This approach is particularly valuable in regions with limited access to formal manufacturing infrastructure or standardized components, where innovation often arises from necessity. For instance, an improvised grinder might incorporate an old fan motor, a bicycle chain, or repurposed wood, and its design could vary depending on its intended use—such as grinding grain, sharpening tools, or processing food. The uniqueness of each grinder reflects the user's available materials, technical skill, and immediate needs, fostering a culture of customization and problem-solving. This design philosophy empowers individuals to become makers and innovators despite constraints, aligning with the idea of "jugaad," a concept from India that refers to ingenious, resourceful solutions born from scarcity (Thatte, 2018)[22].

Improvisation in design encourages risk-taking, negotiation, and responsiveness to uncertainty, enabling creators to move fluidly across different stages of the design process (Sarantou & Miettinen, 2019). It also promotes creative collaboration, spontaneity, and innovation in design work (Gerber, 2007)[23]. When addressing challenges in developing regions, adaptive design principles advocate for simplicity, prototyping, and analysis techniques like load path analysis, all of which contribute to sustainable and context-appropriate solutions (Andersen & Kim, 2011)[24]. Ultimately, this approach celebrates local ingenuity and highlights the potential of adaptive, user-driven design in transforming everyday materials into effective tools.

Conceptual Framework. The ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) is a systematic approach used in various educational contexts. In application, the ADDIE model provides a structured framework for analyzing needs, designing solutions, developing materials, implementing interventions, and evaluating outcomes.

The **Analysis** phase is the foundation of the ADDIE model, focusing on identifying the problem, target audience, and specific goals of a project or instructional program. In this phase, data is gathered to understand the needs and challenges faced by stakeholders, such as teachers, students, or users. For the biodegradable waste grinder project, this stage involved evaluating the issue of waste mismanagement in schools and determining the essential features required for the grinder. By clearly defining objectives and constraints, the analysis phase ensures the project is grounded in addressing real-world needs effectively.

The **Design** phase involves creating a blueprint or detailed plan to address the goals and challenges identified in the analysis phase. It includes specifying the components, structure, and functionality of the solution, as well as planning the instructional materials if used in an educational setting. For the waste grinder, this phase included determining the materials, such as the grinding blade, pounding grills, and electrical components, while ensuring safety and efficiency.

The **Development** phase is where the plans from the design stage are transformed into a tangible product or prototype. This involves building, fabricating, and assembling components based on the design blueprint. For the waste grinder, development included constructing the grinder case, installing the motor and grinding blade, and assembling the feeder, strainer, and pushcart. This phase also includes troubleshooting and refining the product as it takes shape.

The **Implementation** phase focuses on deploying the product or solution in a real-world context. For the biodegradable waste grinder, this involved introducing the device to schools, demonstrating its use to teachers and students, and integrating it into the waste management system. Feedback is collected during implementation to identify any immediate areas for improvement, making this phase critical for practical validation.

The **Evaluation** phase assesses the effectiveness of the solution or program in meeting its objectives. This phase includes both formative evaluations, conducted throughout the development and implementation stages, and summative evaluation, performed after deployment to measure overall success. For the waste grinder, evaluation

involved gathering feedback from teachers, students, school heads, and experts on its functionality, safety, efficiency, and usability.

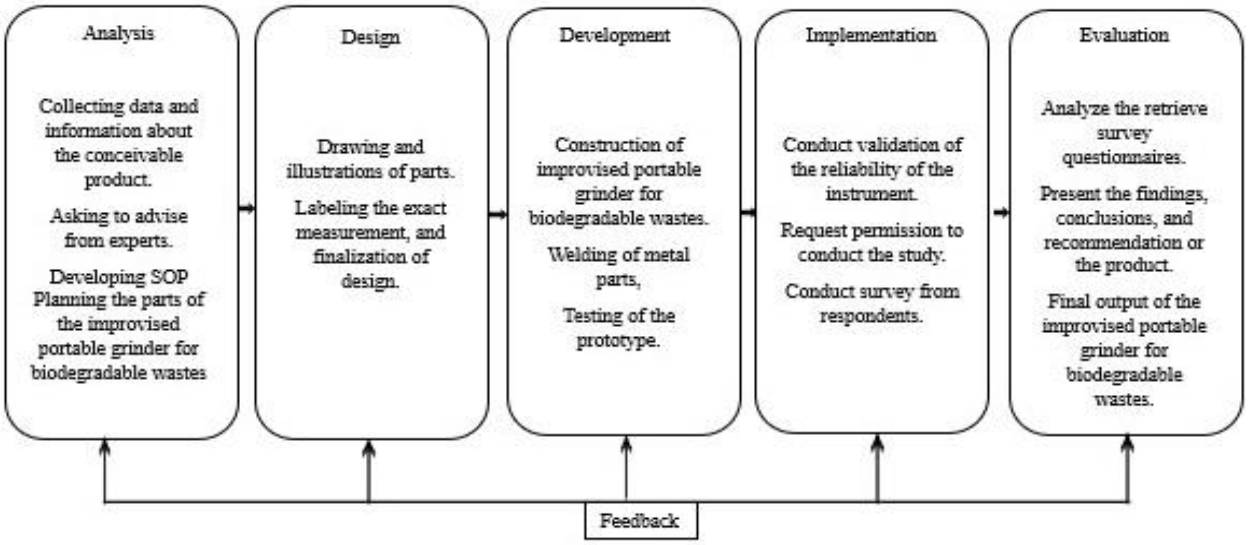

Fig -2: Conceptual Framework of the Study

Bringing all these principles together, the Improvised Portable Grinder becomes more than a simple tool—it becomes a symbol of resourcefulness, sustainability, and localized innovation. It shows how, even with limited resources, individuals and communities can create technologies that are not only functional but also environmentally conscious and socially empowering. This framework offers valuable insights for educators, engineers, and development workers interested in promoting sustainable and inclusive technological solutions. It highlights that great innovation doesn't always come from high-tech labs—it often begins with a need, a creative mind, and a deep understanding of the principles that guide responsible and effective design.

1.7 The Present Study

Despite advancements in waste management technologies, a significant research gap remains in addressing biodegradable waste disposal in resource-limited settings. Current solutions, such as IoT-based smart bins and advanced automation systems, often require substantial infrastructure and high financial investment, making them inaccessible to rural and semi-urban areas in developing countries. This gap underscores the need for practical, affordable, and localized innovations that specifically address biodegradable waste. The improvised portable grinder's relevance lies in its ability to address biodegradable waste issues in low-resource settings effectively. By converting organic waste into fertilizer for initiatives like "gulayan sa paaralan" (school gardens), it promotes sustainability, improves environmental health, and supports local agricultural practices. This innovation bridges the gap between advanced technological solutions and the practical needs of resource-limited communities, offering a scalable and cost-effective approach that contributes to global efforts in sustainable development and environmental preservation.

The reviewed studies highlight distinct differences compared to the present study. While previous innovations focus on urban environments and rely on high-tech systems, the improvised portable grinder for biodegradable waste offers a practical alternative tailored to low-resource contexts. Its simple electric motor, push-cart design, and user-friendly operation make it suitable for use in schools, neighborhoods, and underserved communities. Unlike costly and complex systems, this portable grinder transforms biodegradable waste, such as food remnants and leaves, into fertilizer, aligning with sustainable practices and providing an accessible solution for waste management challenges.

This study aimed to develop and determine the acceptability of the improvised portable grinder for biodegradable wastes. Specifically, it sought to answer the three given objectives: a. determine the processes involved

in developing the device, b. describe the features of the developed device, and c. determine the acceptability of the developed device in terms of functionality, mobility, durability, efficiency, and safety.

2. METHODOLOGY

2.1 Research Design

This study aimed to develop and determine the acceptability of the improvised portable grinder for biodegradable wastes. Specifically, it sought to answer the three given objectives; (a) determine the processes involved in developing the device, (b) describe the features of the developed device, and (c) determine the acceptability of the developed device in terms of functionality, mobility, durability, efficiency, and safety.

The study employed a developmental-survey research design. It was developmental in the sense that it focused on the development of an improvised portable grinder specifically for school waste. To measure the acceptability of the developed product, the study utilized a survey questionnaire to assess its functionality, mobility, durability, efficiency, and safety.

2.3 The Respondents

The source of data for this study were respondents from public schools in Bulan, Sorsogon. The researcher used purposive sampling to determine and select the appropriate respondents for the research. The goal of purposive sampling was to focus on characteristics of a population that were of interest to the study (Ames, 2019).

Table -1 : The Respondents

Respondents	F	Percentage
Teachers	15	30
Students	30	60
Experts	5	10
Total	**50**	**100**

Table 1 presents the study's respondents. A total of 50 respondents participated in the study: fifteen (15) teachers, thirty (30) students, and five (5) experts on the acceptability of the developed device. These respondents were selected using purposive sampling.

2.4 Research Ethics

This study involves various ethical considerations to safeguard both the researcher and his respondents in the conduct of this study.

First, it should be ensured that the respondents are informed about the study and give their consent before the start of any data gathering and collection. No respondent shall be forced into the research, and they shall have the right to withdraw anytime without any risk. All valuable information about this study shall be discussed with them before any interview and/or evaluation sheets to be answered.

Along with the data privacy law of the Philippines, it shall also be guaranteed that anonymity or confidentiality shall be always observed to keep and protect the respondent's privacy. Lastly, it shall be ensured that no lasting physical or psychological harm shall result from the respondents' participation in this study. The researcher shall do everything to follow these research ethics before, during, and after the conduct of the data collection processes.

2.5 Research Instrument

The research instrument employed in this study was a questionnaire designed to evaluate the acceptability of the developed improvised portable grinder for biodegradable waste. The instrument assessed five critical variables: Functionality, Mobility, Durability, Efficiency, and Safety, using a five-point Likert scale. Respondents were asked to rate each indicator based on their observations and evaluations during the actual presentation and demonstration of the product.

The Functionality section focused on evaluating the operational aspects of the grinder. Indicators included the effectiveness of the feeder, grinding blade wheels, safety devices, and the overall operation of the product. This ensured that the grinder was capable of performing its intended functions effectively and safely.

The Mobility section assessed the ease of moving the grinder, emphasizing features like the functionality of the pushcart, the ease of assembly, and the proportionality of the product's weight to its design. These indicators aimed to determine whether the grinder could be conveniently transported and used in various school settings.

In the Durability section, respondents evaluated the grinder's robustness and longevity. This included its ability to grind hard biodegradable waste, operate for extended periods, and the availability of replacement parts. The safety of the product components and the accessibility of its operations were also considered to ensure practicality and reliability.

The Efficiency section focused on the grinder's cost-effectiveness, time-saving qualities, and its ability to produce outputs suitable for composting or vermiculture. Indicators in this section emphasized the use of locally available materials and the overall economic value of the grinder.

Finally, the Safety section evaluated compliance with safety standards and the reliability of the product's safety mechanisms. Respondents rated the functionality of electrical components, grinding blade wheels, and other safety features to ensure the grinder was safe for users and met necessary regulations.

For the validation of the survey questionnaire, five (5) experts were purposively selected: one (1) expert from MENRO, Bulan, Sorsogon; and, four (4) experts from Sorsogon State University, Sorsogon City. The composition of these five (5) experts are the following: one environmentalist, one Mechanical Engineer and three Electrical Engineers. This was done to ensure that respondents had the proper knowledge and background to provide a justifiable assessment of the acceptability of the developed improvised portable grinder for biodegradable waste.

2.6 Data Collection

To obtain the necessary data for this study, the researcher followed the following procedures: First, the researcher sought approval from various authorities by securing a permission letter to conduct the study. The letter was signed by the Graduate School Dean and the researcher's adviser and approved by the DepEd Division Superintendent and the School Principal where the respondents were located. Secondly, these approved letters were personally delivered to the concerned school.

The actual survey of the respondents started on October 14, 2024, after the development of the device was completed with 100% retrieval rate. A demonstration of the use of the developed device was conducted, accompanied by the recording of feedback and reactions from the respondents. The acceptability of the developed improvised grinder for biodegradable waste went on the final evaluation by the respondents based on their hands-on experience with the prototype dated October 28, 2024.

2.7 Data Analysis

To determine the acceptability of the developed portable grinder in terms of functionality, mobility, durability, efficiency and safety, frequency count and weighted mean were used, and a 5 point-Likert scale was also employed to provide adjectival interpretation. The researcher examined the results of the gathered data thoroughly. The data collected were recorded, tabulated, and subjected to statistical analysis and interpretation. The study used frequency count to quantify responses and occurrences while the weighted mean was used to assess the acceptability of the developed improvised portable grinder for biodegradable waste based on the specified variables.

A Likert Scale was also employed to provide an adjectival interpretation of the results. The scale included the following descriptions:

Rating Scale		**Description**
4.50 – 5.00	-	Strongly Agree (SA)
3.50 – 4.49	-	Agree (A)
2.50 – 3.49	-	Fairly Agree (FA)
1.50 – 2.49	-	Disagree (D)
1.00 – 1.49	-	Strongly Disagree (SD)

3. RESULTS and DISCUSSION

3.1 Processes involved in the development of the device

The process flow outlines the step-by-step procedures involved in the construction of the improvised portable grinder for biodegradable waste. This is clearly shown in the flow chart in Figure 3.

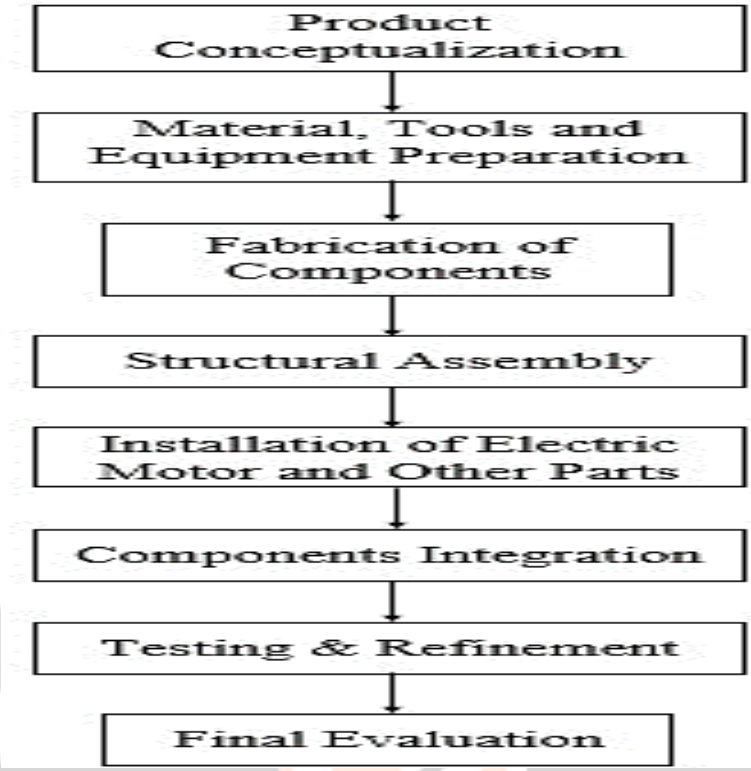

Fig -3: The Flow Chart

Product Conceptualization & Material Preparation - Initially, the researcher proposed a garbage stand with three bins, one with a grinder for biodegradable waste. However, during his title defense, the panelists suggested focusing solely on a biodegradable waste grinder for school waste, leading to a refined project title. To design the grinder blade, he studied blenders and traditional cacao and corn grinders but found them ineffective for grinding leaves. he modified the blade design, making it thicker and incorporating an electric motor for better efficiency.

Material, Tools and Equipment Preparation - Material selection was also crucial. While considering a large tube for the grinder case, fabrication experts suggested repurposing a gasul tank, which proved practical and cost-effective. The materials are (1) Grinding Blades: Designed to chop and crush biodegradable waste into smaller pieces for easier decomposition. (2) Pounding Grills: Installed inside the grinding case to help break down waste during the grinding process. (3) Platform: Provides a stable base for mounting the grinder. (4) Pushcart Framework: Adds mobility, allowing the grinder to be transported easily.

Fig -4: Material, Tools and Equipment Preparation

Fabrication of Components - Individual components such grinding blades, pounding grills, the platform and the pushcart framework were fabricated. Grinding blades were securely attached to the grinding wheel. Pounding grills were welded inside the grinding case.

Fig -5: Fabrication of Components

Structural Assembly - The fabricated components were assembled into a cohesive structure. The platform and pushcart framework were integrated to provide mobility and stability. The grinding wheel and related components were connected to the structural framework.

Fig -6: Structural Assembly

Installation of the Electric Motor and Other Parts - An electric motor was installed and connected to the grinding mechanism using belt pulleys. This set up ensured smooth and effective operation of the grinding process. The electric motor was wired with safety precautions, including the installation of an overload protector and a heavy-duty plug. A switch was added for operational convenience, completing the electrical setup.

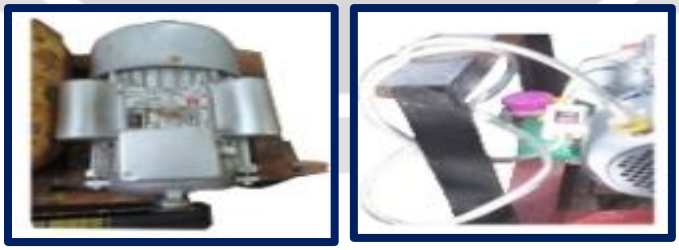

Fig -7: Installation of the Electric Motor & Other Parts

Component Integration Stage - Key parts, including the grinding blade wheel, feeder, strainer, and de-clogger, were fitted precisely into the grinding case. The pushcart was attached to the grinder, enhancing its mobility and usability in different settings.

Fig -8: Component Integration

Testing and Refinement Stage - Initial test runs were conducted to evaluate the grinding efficiency and overall performance. Issues such as blade misalignment, clogging or structural instability were identified and addressed. Iterative adjustments were made to optimize the grinder's functionality, durability and user-friendliness.

Fig -9: Testing and Refinement Stage

Final Evaluation Stage - After testing and refinement, the completed grinder was assessed to ensure that it met the design objectives as a functional and practical solution for managing biodegradable school waste.

Fig -10: Final Evaluation Stage

Design

The improvised portable grinder for biodegradable waste was developed with a strong emphasis on practicality, ease of movement, and user safety. Its main components included a durable grinding blade wheel capable of efficient shredding, a material feeder to direct waste into the grinder, and a strainer for sorting the processed material. To increase usability in school environments, a pushcart base was incorporated, enabling convenient transport between locations. Safety considerations were integral to the design, incorporating features such as an overload protector and a heavy-duty electrical plug to prevent accidents. This user-oriented design approach aimed to create a reliable, efficient solution tailored specifically for managing biodegradable waste in educational settings.

Fabrication

Constructing the grinder required the precise welding and assembly of its various parts to ensure both functionality and resilience. The grinding blades were mounted onto the grinding wheel with secure fastening to endure the operational forces, while the pounding grills were welded inside the chamber to maintain their position during prolonged use. A sturdy frame was built to support the platform and integrated pushcart, ensuring the unit remained stable yet portable. The electric motor, essential for the grinder's operation, was connected to the blade mechanism using belt pulleys, enabling consistent and efficient performance. Each stage of fabrication was handled with attention to detail to guarantee that components aligned correctly and functioned as intended, resulting in a durable and dependable machine.

Working Operation

The operation of the grinder was designed to be straightforward and user-friendly. The electric motor, with its 2-horsepower capacity, powered the grinding mechanism, enabling efficient processing of biodegradable materials. The device was equipped with a switch for easy control, while the overload protector and safety features ensured secure and reliable use. During testing, the grinder's performance was evaluated for efficiency in shredding materials and ease of operation. Issues such as blade misalignment or clogging were identified and resolved, resulting in a refined product that met the objectives of functionality, durability, and safety. The working operation demonstrated the grinder's capability to process biodegradable school waste effectively, converting it into materials suitable for composting or other eco-friendly applications.

3.2 **Features of the Developed Device**

The portability, use of recycled materials, and cost-effectiveness of the developed improvised portable grinder emphasized its practical design, sustainable production, and affordability for schools.

Portability

The improvised portable grinder was designed with mobility as a key feature. Its pushcart design allows the device to be easily transported across various school settings, ensuring flexibility in its use. The lightweight yet sturdy construction ensures that a single person can move the grinder without much effort. The integration of wheels and a stable frame further enhances its portability, making it suitable for both indoor and outdoor waste management tasks. This portability addresses the practical needs of schools with limited fixed waste processing facilities or those located in remote areas.

Use of Recycled Materials

The improvised portable grinder was fabricated using recycled scrap materials, emphasizing sustainability and cost-efficiency. Scrap materials refer to discarded or leftover items—such as metal bars, sheets, and containers—that are no longer usable for their original purpose but can be repurposed for new functions. In this case, key components like the frame and grinding case were constructed from a used *Gasul* tank and scrap angle bar, effectively minimizing waste and reducing the need for new raw materials. An empty *Gasul* tank, made of thick steel, served as a durable and heat-resistant housing for the grinder's motor and mechanism. A gallon top cover, often from old paint cans or water jugs, was repurposed as a dust cover or guard. Scrap flat bars provided support for the motor mounts and tool rests, while scrap angle bars, known for their L-shaped structure, reinforced the corners and base of the frame. This resourceful use of discarded materials not only reduces environmental impact but also showcases how sustainable

practices can be applied in practical tool fabrication. Together, these materials offer a low-cost, sustainable way to create a functional and safe portable grinder using recycled components.

Cost-Effectiveness

The cost-effectiveness of the improvised grinder was a central consideration during its development. By utilizing recycled materials and simple mechanical components, the overall production cost was kept to a minimum. The reliance on locally sourced materials further reduced expenses, making the grinder an affordable solution for schools with limited budgets. Additionally, the device's ability to process biodegradable waste efficiently into materials suitable for composting eliminates the need for costly commercial waste management services, offering long-term economic benefits to schools. This cost-effective approach ensures the grinder is accessible to a wider range of schools, particularly those in resource-constrained settings.

Table 2: Materials Cost

Materials	Cost	Materials	Cost
Side Cover	₱ 600.00	Cable wire	177.00
Feeder	1,000.00	Male plug	57.00
Flat bar	2,400.00	Overload protector	900.00
Angle bar	1,200.00	Bolt & Nuts	500.00
Round bar	600.00	Wheels	1,000.00
Chicken Wire	150.00	Grinding Wheel Blade	5,000.00
Square Bar	150.00	Grinding Case	500.00
Flange bearing	2,700.00	Pounding Grill	1,000.00
Belt pulley	900.00	**Total Material Cost**	₱ 28,834.00
Pulley	1,000.00	**Labor Cost**	10,000.00
Electric motor	9,000.00	**TOTAL COST**	**₱ 38,834.00**

3.3 **Parts of the Developed Device**

A. Grinding Case

The grinding case serves as the housing for the grinding wheel blade and the pounding grill. It features three main openings: one for the feeder, where biodegradable waste is loaded; another for the strainer, through which finely processed waste exits; and a de-clogger hole, designed to address and clear any clogs that may occur during operation.

Fig -11: Grinding Case

B. Grinding Blade Wheel

The grinding blade wheel is constructed using a thick flat bar, welded to a sturdy round tube. The blades are linear in shape with a central hole. They are mounted on a round bar, arranged with a 1-inch gap between each blade, and a total of eleven blades are installed in a ladder-like configuration. The grinding blade wheel is securely attached to the grinding case using two flange bearings.

Fig -12: Grinding Blade Wheel

C. Pounding Grills

The pounding grills welded in a row with a 1.5-inch gap between them. These grills work in tandem with the grinding blade, ensuring that the waste is finely ground as it passes through.

Fig -13: Pounding Grills

D. Feeder

The feeder, designed to resemble a funnel, serves as the entry point for the waste to be ground. It includes an opening with a closure mechanism to prevent overflow during the grinding process. The feeder is crafted from a flat sheet of medium-thickness material, ensuring durability and functionality.

Fig -14: Feeder

E. Strainer

The strainer is positioned at the bottom to ensure that only finely processed waste exits the grinder. It measures 4 inches by 7 inches, with screen holes sized at ½ inch for effective filtration. Additionally, the grinder features a front-facing round hole with a diameter of 5 inches. This opening includes a closure mechanism and functions as a de-clogger, allowing for easy clearing of blockages during operation.

Fig -15: Strainer

F. Platform

The platform is constructed using angle bars. It is welded into a rectangular frame. This sturdy platform serves as the base for the electric motor and grinder, which are securely mounted and connected via two belt pulleys for efficient operation.

Fig -16: Platform

G. Electrical Component

The grinder is powered by a single-phase electric motor. It is equipped with a 2-meter electrical cord (gauge 2.0) and a heavy-duty male plug. For safety and ease of use, the motor is fitted with a switch and an overload protector, ensuring protection against potential overloading during operation.

Fig -17: Electrical Component

H. Pushcart

The pushcart is constructed using angle bars. It designed for easy handling and operation. The pushcart is equipped with wheels measuring 5 inches in diameter, ensuring smooth mobility. It serves as a convenient and sturdy base for transporting the grinder.

Fig -18: Pushcart

I. Finished Product

The final product is a durable and efficient **biodegradable waste grinder** designed for school waste management. It features a sturdy grinding case housing an 11-blade wheel and pounding grills, ensuring thorough processing of biodegradable materials. The grinder includes a funnel-shaped feeder for easy waste input, a strainer for fine output, and a declogger for clearing blockages. Powered by a 2-horsepower single-phase electric motor with safety features like an overload protector, the grinder is mounted on a stable rectangular platform with belt pulleys for smooth operation. For added convenience, it is equipped with a pushcart made of durable angle bars and wheels, allowing easy mobility and adaptability to various settings.

Fig -19: Finished Product

3.4 The Acceptability of the Developed Device

The acceptability of the developed improvised portable grinder for biodegradable waste is grounded in its functionality, mobility, durability, efficiency and safety, and contribution to environmental sustainability. The device effectively processes biodegradable waste into fine material suitable for composting, addressing a key waste management issue in schools. Its user-friendly design, safety features, and mobility make it accessible for educational settings. Feedback from stakeholders highlights its potential to promote sustainable practices and support school gardening initiatives like "Gulayan sa Paaralan." Overall, the device is well-received as an innovative and efficient solution for managing biodegradable waste in a school environment.

Functionality

Table 3 presents the functionality category, which achieved an overall mean score of 4.28, indicating that respondents found the grinder to be acceptable in carrying out its intended tasks.

The functionality of the improvised grinder was assessed by four groups of respondents: Teachers, Students, School Heads, and Experts, revealing diverse perspectives on its performance. Teachers and School Heads rated the grinder most favorably, with overall weighted means (WM) of 4.64 (Strongly Agree) and 4.87 (Strongly Agree), respectively.

In contrast, Students provided the most critical evaluation, assigning the lowest overall rating of 3.57 (Agree). They rated the feeder's width at 3.30 (Fairly Agree), the lowest score among all groups, reflecting concerns about its capacity to support multiple biodegradable waste inputs.

Table 3: Functionality of the Improvised Grinder

Indicators	Teachers		Students		Sch Heads		Experts	
	WM	I	WM	I	WM	I	WM	I
The Feeder is wide enough to support multiple biodegradable waste.	**4.33**	A	**3.30**	FA	4.33	A	4.20	A
Grinding Blade Wheels are functional.	4.73	SA	3.53	A	5.00	SA	4.00	A
Safety devices such as switches and electric motor are operational.	4.60	SA	3.60	A	5.00	SA	4.00	A
The electric motor switch is operational.	**4.80**	SA	**3.80**	A	5.00	SA	4.00	A
The product as a whole is fully operational.	4.73	SA	3.60	A	5.00	SA	4.00	A
Overall WM	**4.64**	**SA**	**3.57**	**A**	**4.87**	**SA**	**4.04**	**A**
				Overall Grand Mean			**4.28**	**A**

Legend: SA – strongly agree A – agree FA – fairly agree

The differences in ratings among the four groups have significant implications for the future development and deployment of the improvised grinder. The strong endorsements from Teachers and School Heads suggest the grinder is effective in controlled, professional settings. However, the lower ratings from Students highlight potential challenges in usability, indicating that end-users may encounter difficulties in operating the grinder efficiently.

The moderate ratings from experts highlight the need for technical improvements in the grinder, particularly in enhancing safety devices and ensuring consistent operational performance, while students pointed out usability issues such as limited feeder capacity.

Mobility

Table 4 illustrates the mobility of the device, which received an overall mean score of 4.53, suggesting that respondents found it easy to move and assemble. The mobility of the improvised grinder was assessed by four groups of respondents: Teachers, Students, School Heads, and Experts, resulting in diverse ratings and interpretations. School Heads and Experts gave the highest ratings, with overall weighted means (WM) of 5.00 (Strongly Agree) and 4.96 (Strongly Agree), respectively, indicating a strong endorsement of the grinder's portability and user-friendly design. These groups rated all indicators consistently high, especially the product's ability to be moved, assembled, and operated efficiently by a single person.

Teachers also provided a high overall rating of 4.68 (Strongly Agree), showing satisfaction with the grinder's mobility. However, they rated the grinder's ability to be moved by a single person slightly lower at 4.40 (Agree), indicating potential challenges with weight or balance. Despite this, they viewed the operational pushcart features and ease of assembly positively, both rated at 5.00 (SA).

Students, once again, provided the most critical ratings with an overall WM of 3.47 (Fairly Agree). They rated the grinder lowest for its ability to be moved by a single person (3.07, Fairly Agree) and expressed moderate agreement on its operational features and proportional weight.

Table 4: Mobility of the Improvised Grinder

Indicators	Teachers		Students		Sch Heads		Experts	
	WM	I	WM	I	WM	I	WM	I
The product can be moved from one place to another.	4.93	SA	3.53	A	5.00	SA	5.00	SA
Pushcart features are operational and working properly.	5.00	SA	3.70	A	5.00	SA	4.80	SA
The parts of the product can be assembled easily.	4.53	SA	3.53	A	5.00	SA	5.00	SA
The weight of the product is proportioned to its physical appearance.	4.53	SA	3.50	A	5.00	SA	5.00	SA
The product can be moved by a single person	4.40	A	3.07	FA	5.00	SA	5.00	SA
Overall WM	4.68	SA	3.47	FA	5.00	SA	4.96	SA
				Overall Grand Mean			4.53	SA

Legend: SA – strongly agree A – agree FA – fairly agree

Durability

Table 5 shows the durability which received an overall mean score of 4.46. The durability of the improvised grinder was evaluated by four groups of respondents: Teachers, Students, School Heads, and Experts, yielding varying perceptions about its robustness and functionality. School Heads and Experts provided the highest overall ratings, with weighted means (WM) of 4.78 (Strongly Agree) and 4.83 (Strongly Agree), respectively. These ratings highlight their confidence in the grinder's ability to withstand extended use and process hard biodegradable materials, as well as the accessibility of replacement parts and materials.

Table 5: The Durability of the Improvised Grinder

Indicators	Teachers		Students		Sch Heads		Experts	
	WM	I	WM	I	WM	I	WM	I
The product can grind hard biodegradables such as twigs and chopped tree branches	4.20	A	3.23	A	4.33	A	4.80	SA
The product can operate for 30 minutes or more.	4.73	SA	3.57	A	5.00	SA	5.00	SA
The parts and components of the product can be easily replaced when damaged or has defect.	4.80	SA	3.50	A	5.00	SA	5.00	SA
The product is equipped with convenient safety devices and locks to ensure safety of product parts	4.80	SA	3.60	A	4.33	A	4.20	A

All materials used on the product are readily available in the market	4.87	SA	3.43	FA	5.00	SA	5.00	SA
The operation is accessible, can be easily operated and used.	4.87	SA	3.70	A	5.00	SA	5.00	SA
Overall WM	4.71	SA	3.51	A	4.78	SA	4.83	SA
			Overall Grand Mean				4.46	SA

Legend: SA – strongly agree A – agree FA – fairly agree

Teachers also rated the grinder favorably, with an overall WM of 4.71 (Strongly Agree). They particularly appreciated the availability of materials used in the grinder (4.87, SA) and its ease of operation (4.87, SA). However, they provided a slightly lower rating of 4.20 (Agree) for the grinder's ability to process hard biodegradables, suggesting some reservations about its performance with tougher materials. Despite this, Teachers generally viewed the grinder as durable and reliable.

Students, however, were more critical, assigning the lowest overall rating of 3.51 (Agree). They rated the grinder's ability to process hard biodegradables at 3.23 (Agree) and its accessibility of materials at 3.43 (Fairly Agree), indicating concerns about its effectiveness and availability of replacement parts. The highest rating from Students was 3.70 (Agree) for ease of operation, reflecting moderate satisfaction with this aspect. These ratings suggest that Students found the grinder less durable and user-friendly compared to the other groups.

Efficiency

Table 6 presents the efficiency of the device, which scored an impressive overall mean of 4.56, with respondents particularly noting its ability to save time and produce compost-ready output. The efficiency of the improvised grinder was evaluated by four groups of respondents: Teachers, Students, School Heads, and Experts. The results revealed varying levels of satisfaction, with School Heads and Experts providing the highest overall ratings, weighted means (WM) of 4.87 (Strongly Agree) and 5.00 (Strongly Agree), respectively. These groups consistently rated all indicators positively, reflecting their strong belief in the grinder's efficiency, cost-effectiveness, and ability to produce usable outputs for fertilization or vermiculture. The highest ratings for these groups included 5.00 (SA) for the grinder's cost-efficiency and the availability of materials needed for its construction, emphasizing its practicality and sustainability.

Table 6: Efficiency of the Improvised Grinder

Indicators	Teachers		Students		Sch Heads		Experts	
	WM	I	WM	I	WM	I	WM	I
The materials used are economical but of good quality.	4.60	SA	3.73	A	5.00	SA	5.00	SA
All materials needed in constructing the product are locally available.	4.73	SA	3.67	A	5.00	SA	5.00	SA
Grinding using the product can save more time and effort due to its efficiency in crushing biodegradable wastes	4.87	SA	3.50	A	5.00	SA	5.00	SA
The produced output can be readily introduced as fertilizer or can be fed in a vermiculture setting.	4.93	SA	3.67	A	4.33	A	5.00	SA
The best cost efficiency of the product is achieved.	4.67	SA	3.53	A	5.00	SA	5.00	SA

Overall WM	4.76	SA	3.62	A	4.87	SA	5.00	SA
				Overall Grand Mean			4.56	SA

Legend: SA – strongly agree A – agree FA – fairly agree

Teachers also rated the grinder favorably, with an overall WM of 4.76 (Strongly Agree). They highlighted the product's ability to produce outputs ready for use as fertilizer (4.93, SA) and its time-saving grinding efficiency (4.87, SA) as key strengths. Their ratings indicate confidence in the grinder's performance and alignment with the intended purpose of efficient biodegradable waste processing.

Students, however, provided more moderate evaluations, with an overall WM of 3.62 (Agree). They were the most critical of the grinder's efficiency in terms of cost-effectiveness (3.53, Agree) and its ability to save time and effort during grinding (3.50, Agree). Despite this, Students agreed that the materials used were of good quality and locally available (3.73, Agree) and that the produced output could be used in fertilization (3.67, Agree). These ratings suggest that while Students acknowledged the grinder's utility, they perceived limitations in its practicality and efficiency compared to the other groups.

Safety

Table 7 presents the safety of the device, which received the highest overall mean score of 4.50, with particular praise for compliance with safety standards and effective safety mechanisms. The safety of the improvised grinder was evaluated by Teachers, Students, School Heads, and Experts, revealing significant differences in perceptions across the groups. School Heads and Experts provided the highest overall ratings, with weighted means (WM) of 5.00 (Strongly Agree) and 4.60 (Strongly Agree), respectively. These groups highlighted the product's compliance with safety standards and its effective safety mechanisms. School Heads rated all indicators as **5.00 (SA)**, reflecting their strong confidence in the grinder's adherence to safety protocols, functionality of its safety features, and protection against malfunctions.

Teachers also gave high ratings, with an overall WM of 4.89 (Strongly Agree). They emphasized the compliance of electrical materials with the Philippine Electrical Code (5.00, SA) and the proper operation of safety mechanisms such as the grinding blade wheels and motor (4.87, SA). These ratings indicate that Teachers recognize the grinder as a safe and reliable tool, with a high level of trust in its safety measures.

Students, on the other hand, provided more moderate ratings, with an overall WM of 3.51 (Agree). They were most critical of the safety devices and mechanisms, giving a rating of 3.47 (Fairly Agree) for the functionality of the electric motor switch and overload protector. While they agreed on the emphasis on safety features (3.63, Agree) and the proper operation of safety mechanisms (3.50, Agree), their lower scores suggest concerns about the grinder's user safety and reliability.

The comparison reveals that while the grinder's safety features are strongly endorsed by School Heads, Experts, and Teachers, the concerns raised by Students indicate potential areas for improvement. The high ratings from School Heads and Experts emphasize the grinder's compliance with safety standards and effective protective mechanisms, suggesting that the product is well-suited for professional and technical applications.

Table 7: Safety of the Improvised Grinder

Indicators	**Teachers**		**Students**		**Sch Heads**		**Experts**	
	WM	I	WM	I	WM	I	WM	I
The electrical materials used are of an approved type and are in compliance with the provisions of the Philippine Electrical Code and other standards.	5.00	SA	3.43	A	5.00	SA	4.20	A
Electric motor switch, overload protector and other devices respond	4.87	SA	3.47	A	5.00	SA	5.00	SA

to the safety of the product and the user.								
Grinding blade wheels and electric motor are safe from malfunctions and properly operate.	4.87	SA	3.50	A	5.00	SA	4.80	SA
All safety mechanisms work properly and can be easily troubleshoot.	4.87	SA	3.50	A	5.00	SA	4.80	SA
Safety features are emphasized in the product.	4.87	SA	3.63	A	5.00	SA	4.20	A
Overall WM	4.89	SA	3.51	A	5.00	SA	4.60	SA
					Overall Grand Mean		4.50	SA

Legend: SA – strongly agree A – agree FA – fairly agree

3.5 DISCUSSION

Development and Construction Flows

The development of the improvised portable grinder for biodegradable waste followed a systematic and iterative process grounded in practical design, resource efficiency, and responsiveness to stakeholder feedback. The entire procedure is encapsulated in a process flow diagram, which illustrates the methodical steps taken from conceptualization to final evaluation.

In the materials, tools, and equipment preparation stage, the researcher prioritized the use of accessible, repurposed components. Notably, instead of sourcing a new grinding case, a used *Gasul tank* was repurposed, demonstrating a sustainable and cost-effective approach. The key components—grinding blades, pounding grills, platform, and pushcart framework—were carefully selected for their functionality: the blades for chopping, the grills for waste breakdown, the platform for stability, and the pushcart framework for mobility.

The fabrication of components was followed by the structural assembly phase, where individual elements were brought together into a cohesive system. The modular approach to building allowed for precision in fitting parts, which later facilitated easier troubleshooting during testing. An essential phase was the installation of the electric motor and electrical system. Beyond mere operational functionality, this stage underscored safety considerations. The inclusion of a heavy-duty plug, an overload protector, and a dedicated switch reflected an emphasis on protecting both the equipment and the user. The belt pulley system, connecting the motor to the grinding blade wheel, allowed for smooth transmission of mechanical energy while minimizing vibration and noise. The component integration stage unified all major parts into the final build. Critical components such as the feeder, strainer, and de-clogger were installed to improve usability, output control, and system cleanliness. The pushcart feature also enhanced the practicality of the design, making the grinder suitable for deployment in varied school environments. Following full assembly, the testing and refinement stage was conducted. Initial trials revealed operational challenges, such as blade misalignment and occasional clogging. These were addressed through iterative improvements, demonstrating the importance of continuous evaluation in engineering design. Adjustments focused on improving the alignment of internal components, reducing the likelihood of waste blockage, and increasing structural stability. Finally, the evaluation phase validated the functionality of the device against its intended objectives. The grinder met its performance criteria by effectively processing biodegradable waste into smaller, more decomposable forms. Moreover, its design offered mobility, safety, and ease of use, making it a suitable solution for school-based waste management initiatives.

The successful development of the improvised portable grinder highlights the potential of localized, low-cost technologies in addressing environmental sustainability at the community level. Schools—where biodegradable waste is regularly generated—can benefit from having an accessible and efficient tool for waste processing.

Innovative Attributes and Specifications

The improvised portable grinder for biodegradable waste was developed with a deliberate focus on practicality, sustainability, and affordability. These three features—portability, use of recycled materials, and cost-effectiveness—collectively define the core strengths of the device and highlight its suitability for use in school environments, particularly those with limited resources.

Portability was a defining feature incorporated into the design from the outset. Recognizing the operational constraints faced by schools, especially those lacking fixed waste disposal facilities or located in remote areas, the grinder was built with a pushcart framework to facilitate mobility. Its lightweight construction, combined with the durability of the frame and the inclusion of wheels, enables a single individual to transport the device with ease. This mobility allows the grinder to be deployed flexibly across various indoor and outdoor school settings, thus enhancing its utility and reach.

The use of recycled materials was another crucial aspect of the device's development. Components such as the grinding case—crafted from a repurposed gasul tank—and the frame, which utilized scrap angle and round bars, demonstrate an innovative approach to resource utilization. This strategy not only reduced the environmental impact of production but also showcased the feasibility of building functional equipment using repurposed items. It reflects a practical response to the global call for sustainable design practices and introduces a replicable model for schools or institutions seeking to build similar devices with minimal ecological footprint.

Equally significant is the device's cost-effectiveness, which underscores its accessibility and appeal to budget-conscious users. The total production cost including labor and materials, was minimized using locally sourced and recycled components. Compared to the acquisition and maintenance of commercial waste processing machines, this improvised grinder presents a far more affordable solution. Moreover, its capacity to convert biodegradable waste into compost-ready material provides long-term financial benefits by reducing the need for external waste management services and supporting school-based ecological projects such as gardening or composting programs.

The device’s structural components were designed with both functionality and safety in mind. The grinding case houses the core operational parts and features three critical openings: one for feeding the waste, one for straining the processed output, and one for manually declogging the system when necessary. This design enhances operational efficiency while minimizing downtime due to clogging. The grinding blade wheel, constructed from thick flat bars arranged in a linear pattern with strategic spacing, ensures effective shredding of biodegradable material. Mounted securely onto a round bar, the eleven blades are engineered to maintain balance and provide consistent cutting performance, essential for high-efficiency waste processing.

The design and development of this improvised portable grinder offer a viable and replicable model for promoting sustainable waste management practices within school settings. By emphasizing affordability, environmental consciousness, and functional mobility, the device addresses a critical gap in localized waste processing tools. Its successful implementation not only empowers schools to take an active role in managing biodegradable waste but also fosters environmental awareness among students and staff. The grinder’s low-cost, sustainable design can inspire further innovations in school-based eco-solutions and potentially influence broader community practices in waste reduction and recycling.

Assessment of the Improvised Device

Functionality The functionality of the improvised portable grinder was broadly acknowledged by respondents, particularly Teachers and School Heads, who highlighted its efficiency and alignment with its intended purpose. Their positive feedback reflects the grinder’s ability to support school-based biodegradable waste management, especially in settings with limited access to commercial waste processing equipment. This affirms Mantaring’s (2024) emphasis on the need for accessible and practical waste management solutions in resource-limited environments.

In contrast, Students expressed reservations regarding the device's user interface, particularly the size of the feeder. Their feedback centered more on ease of use and convenience, suggesting that operational comfort is a significant factor for younger or less experienced users. While adult stakeholders appeared to prioritize the grinder’s functionality and reliability, Students focused on user experience—underscoring the importance of designing with

diverse users in mind. Enhancing aspects such as feeder dimensions and ergonomics could therefore improve the grinder's overall usability and ensure it is more inclusive.

Experts provided a generally favorable assessment, though their feedback suggested room for improvement. While they acknowledged the grinder's core functionality, they pointed to critical areas such as the safety features and operational design as needing further refinement. Their evaluation underscores the value of incorporating design safeguards and quality assurance measures to enhance both user safety and product durability.

These varying perspectives highlight the importance of a user-centered approach to design and refinement. While the grinder performs its core function effectively, integrating user feedback—particularly from younger users—can help address usability gaps and optimize the device for broader application. Improvements in design could expand its relevance beyond educational institutions to include community-based or household use. In general, the findings support Mantaring's (2024) call for adaptable, user-informed innovations in sustainable waste management, reinforcing the need to balance functionality with inclusivity in environmental technology solutions.

Mobility. Mobility was identified as one of the grinder's most notable strengths, particularly by School Heads and Experts who praised its pushcart design, ease of assembly, and transportability across varied school environments. Their positive feedback reflects confidence in the device's practical application, especially in institutional or professional settings where functionality and ease of deployment are critical. The incorporation of a mobile pushcart structure clearly contributed to the grinder's perceived operational efficiency.

However, a contrasting perspective emerged from Student respondents, who provided lower ratings for mobility. Their feedback pointed to challenges related to weight and maneuverability, suggesting that the grinder, while transportable, may not be easily operated by a single user—especially those with less physical strength or technical familiarity. This user-centered insight is particularly important, as it highlights the necessity of ergonomic considerations in design. These findings support the observations of Afolalu et al. (2021), who emphasized the importance of user-centered design in the development of sustainable waste management technologies.

The divergence in feedback across respondent groups suggests that while the grinder's current mobility features serve professional users well, improvements are needed to enhance usability for younger or less experienced operators. Design refinements such as incorporating lighter materials, improving weight distribution, or offering adjustable pushcart components could significantly improve user experience.

In general, the positive ratings from Teachers, Experts, and School Heads affirm that the grinder's mobility features—particularly the pushcart integration and ease of assembly—are functional and effective. Yet, the moderate responses from Students offer valuable direction for future iterations. By addressing these limitations, the grinder can become a more inclusive, user-friendly, and sustainable solution suited for broader adoption in both educational and community settings.

Durability. The grinder's durability emerged as a significant strength, particularly in the evaluations provided by School Heads, Experts, and Teachers. These groups consistently acknowledged the device's robust construction and its capacity for extended use, especially in professional or educational settings where long-term operation is essential. Their assessments suggest confidence in the structural integrity and resilience of the grinder, affirming its suitability for routine waste processing tasks in schools.

In contrast, Students raised critical observations concerning the grinder's ability to process harder biodegradable materials. This feedback draws attention to potential limitations in the current design, especially for users who may encounter a variety of biodegradable waste types. These insights align with Bathia's (2019) assertion that waste management tools must be equipped to handle diverse material compositions to be truly effective and sustainable. The students' concerns suggest that while the grinder may be durable in structure, its functional durability—specifically the grinding mechanism's capacity to manage tougher waste—is an area that requires improvement.

This contrast in perspectives underscores the need for thoughtful refinement of the grinder's core components. Enhancing the grinding mechanism to accommodate harder or denser materials would not only address the practical concerns raised by students but also improve the device's overall versatility and performance.

Furthermore, ensuring that replacement parts and compatible materials are readily available in the local market would support long-term maintenance and durability, making the device more sustainable and cost-effective over time.

The strong ratings across all respondent groups for features such as extended operational use, safety components, and user-friendly handling affirm critical elements of the design that should be retained in future iterations. However, the constructive feedback from students signals an opportunity to further align the grinder's capabilities with the realities of waste composition in school settings. By reinforcing its grinding mechanism and material handling capacity, the device can evolve into a more comprehensive, reliable, and widely applicable solution for biodegradable waste management.

Efficiency. Efficiency emerged as one of the most positively regarded features of the improvised portable grinder, particularly among School Heads, Experts, and Teachers. These respondents highlighted the device's ability to deliver practical benefits such as cost savings, time efficiency, and the production of usable outputs from biodegradable waste. Their feedback affirms the grinder's relevance as a sustainable and economical solution for educational institutions with limited resources. The strong endorsement from these groups reflects a high level of satisfaction with the device's functionality in structured, goal-oriented settings.

In contrast, Students provided more critical assessments, rating the grinder lower in terms of efficiency. While they recognized its potential benefits, they pointed to operational challenges and issues with output quality. This divergence in perception underscores the importance of considering user experience, especially among end-users who may have less technical familiarity or physical strength. Students' feedback suggests that while the grinder is efficient in theory and professional practice, its ease of operation and consistency of output require refinement to better serve all users, including those less experienced or younger.

These findings align with Conant and Fadem's (2024) emphasis on adapting waste management innovations to meet local and contextual user needs. The variation in feedback emphasizes the necessity of designing user-centered tools that are not only functionally efficient but also intuitive and accessible for diverse user groups. Enhancements such as clearer safety instructions, improved output uniformity, and simplified operational procedures could bridge the gap between perceived and actual efficiency across user demographics.

Moreover, the consistently high ratings for the availability and quality of materials used in the grinder's construction indicate a reliable foundation upon which to build further improvements. These strengths should be preserved in future iterations. However, integrating the feedback from Students is equally important to enhance the grinder's universal appeal. Addressing concerns related to usability and output performance will not only boost user satisfaction but also reinforce the grinder's role as a practical and inclusive solution for biodegradable waste management in educational settings. Ultimately, by refining its design based on user experience, the grinder can achieve greater alignment with the diverse needs of its stakeholders, thus enhancing its impact, adoption, and long-term effectiveness as a localized environmental innovation.

Safety. Safety was consistently recognized as a key strength of the improvised portable grinder, with School Heads, Experts, and Teachers awarding high ratings for its compliance with established safety standards and the inclusion of effective protective mechanisms. Their evaluations underscore the device's adherence to technical guidelines such as the Philippine Electrical Code, suggesting that the grinder is structurally sound and safe for regular use in educational and professional environments. This compliance is a vital strength that supports the grinder's credibility as a sustainable waste management solution.

Despite this, Students expressed reservations about the grinder's safety features, specifically regarding their clarity, reliability, and ease of use. These concerns likely stem from limited user familiarity or experience, highlighting an important dimension of user-centered design—ensuring that safety mechanisms are not only present but also clearly communicated and intuitively operable. The disparity in perceptions suggests that while the device may meet regulatory standards, its real-world usability among less experienced users may still fall short.

These findings support Khajuria's (2010)[25] assertion that community-level waste management tools must prioritize both functional safety and user education. In line with this, improving the **visibility**, **clarity**, and **operational responsiveness** of the grinder's safety features—such as overload protectors, switches, and emergency stop mechanisms—could significantly enhance user trust and engagement, especially among younger or non-technical users.

The consistently high ratings from more experienced evaluators reinforce the importance of maintaining robust safety measures, but the lower assessments from Students suggest a critical area for enhancement. Incorporating visual cues, instructional labels, or even short demonstrations could help ensure that all users, regardless of their technical background, can operate the grinder confidently and safely. Ultimately, addressing these concerns through design refinements and user-oriented safety education will foster a safer, more inclusive user experience. By balancing structural safety with operational clarity, the grinder can more effectively meet the needs of a diverse user base while upholding its reputation as a reliable and secure solution for biodegradable waste processing in educational settings.

4 CONCLUSIONS AND RECOMMENDATIONS

Conclusions. The study highlights the effectiveness and practicality of the improvised portable grinder for biodegradable waste, developed through a systematic process encompassing fabrication, assembly, installation, and testing. The design prioritized functionality, durability, and safety, integrating robust grinding blades, a feeder, a strainer, and a mobility-enhancing pushcart, along with safety features such as an overload protector and a heavy-duty plug. The fabrication process ensured structural stability through precise welding and seamless component integration. Powered by an electric motor, the device effectively processed biodegradable materials into compostable outputs, addressing key challenges in school-based waste management with a cost-effective and environmentally sustainable solution.

Beyond its immediate benefits, the study also identified areas for enhancement to further optimize the grinder's usability and impact. While its portability, use of recycled materials, and cost-effectiveness were well received, user feedback emphasized the need for refinements in operational ease and processing efficiency. Specifically, improvements in ergonomics, automated safety mechanisms, and enhanced grinding efficiency could further increase its practical application. Future research may explore material enhancements, energy efficiency upgrades, and automation features to enhance long-term usability and scalability.

Recommendations. It is highly recommended to enhance the biodegradable waste grinder by increasing its feeder capacity for greater efficiency, using lighter yet durable materials to improve mobility, and strengthening the grinding mechanism for long-term durability. Simplifying safety features, such as motor switches and overload protectors, and providing user manuals are also highly recommended to ensure safer and more user-friendly operation, particularly for students and beginners.

Furthermore, conducting workshops and seminars to train students, teachers, and community members on the proper use and maintenance of the device is highly recommended to reinforce its role in waste management and environmental sustainability. Collaborating with local government units (LGUs) and environmental organizations is also highly recommended to facilitate wider adoption, particularly in resource-limited areas, ensuring maximum impact and long-term viability.

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