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Empowering Students Through Eco-Enzyme Education to Reduce Household Organic Waste

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Abstract

Indonesia faces a growing challenge in managing household organic waste, much of which originates from kitchen leftovers that are often discarded without proper treatment. Communities lack awareness and access to simple, low-cost solutions for processing biodegradable waste at the source. The community service program aimed to address this gap by educating vocational agriculture students on how to transform kitchen waste into eco-enzyme, a multipurpose organic liquid produced through fermentation. The program used a participatory method that combined presentations, discussions, and hands-on practice to enhance student engagement and learning outcomes. Students learned how to measure, mix, and monitor the production of eco-enzymes using locally available materials, such as fruit scraps, water, and brown sugar. The impact was measured using a pre- and post-assessment questionnaire, which was analyzed through the Mann–Whitney U test. This analysis revealed significant improvements in student knowledge, attitude, and willingness to apply eco-enzyme techniques. Field observations confirmed that students responded enthusiastically, showing curiosity and initiative during the practical sessions. The results suggest that integrating experiential environmental education into vocational school programs can help bridge knowledge gaps and inspire sustainable behavior among young people. This initiative demonstrates that empowering students through hands-on environmental learning not only improves understanding but also cultivates long-term ecological responsibility. Schools and policymakers should consider incorporating eco-enzyme training modules into the agricultural curriculum to support local waste reduction efforts and promote sustainability at the grassroots level.

Keywords*: behavioral readiness, community, education, environmental, waste management*

1. INTRODUCTION

Indonesia generates a massive volume of household waste, primarily consisting of organic material from residential kitchens. The country ranks second globally in waste production, with daily output reaching 175,000 tons, where over 75% originates from organic sources (Ruslinda et al., 2020). Most communities lack effective systems for processing biodegradable waste, which contributes to environmental degradation and public health issues. Students, as future agents of change, often remain unaware of simple solutions such as eco-enzyme production using fruit and vegetable waste.

Mounting waste volumes and limited student awareness of eco-sustainability demand immediate educational intervention. Local schools serve as strategic hubs for cultivating environmentally conscious behavior among young people. Delayed action in promoting sustainable waste solutions can exacerbate environmental damage and reduce students' readiness to respond to ecological challenges.

Eco-enzyme education introduces an accessible and environmentally friendly solution to organic waste challenges in local communities. Eco-enzymes are a complex organic compound solution produced through the fermentation of organic waste, sugar, and water. The fermentation process is reported to generate ozone gas (O_3), with the final output being the eco-enzyme solution (Megah et al., 2018). The long-term objective of eco-enzyme research and development is to fulfill a purposes, the mitigation of solid waste and the replacement of synthetic chemicals known to have adverse effects on human health and ecosystems (Muliarta & Darmawan, 2021), it serves as a multi-purpose cleaning agent and an eco-friendly plant fertilizer (Megah et al., 2018), functions as a controller for various plant pests and as an environmental conservator, as eco-enzymes are capable of neutralizing various pollutants that contaminate the environment (Rochyani et al., 2020).

Students benefit from this knowledge by developing critical thinking, ecological awareness, and hands-on skills that can influence sustainable behavior (Arbianti et al., 2024). Community service programs bridge the knowledge gap between waste generation and sustainable management practices, especially in educational settings with agricultural relevance. The implementation of community service programs in education has the potential to empower individuals to recognize the economic viability of waste materials, thereby providing a solution to the ongoing issue of waste accumulation (Nurhayati & Nurhayati, 2023). Current community engagement activities rarely integrate eco-enzyme education into the curriculum of vocational agriculture schools. Many programs focus on theoretical awareness without combining it with practical, scalable action. Students often lack exposure to real-life applications that connect environmental education with personal and community-based waste management initiatives.

The community service programs activities involved designing an interactive education module on eco-enzyme production and application using kitchen waste. The team implemented a structured plan involving lectures, visual presentations, live demonstrations, and collaborative waste-to-product practices among students. These activities took place at SMK Negeri 2 Sukoharjo with students from the Integrated Agricultural Business (UPT) department.

The community service programs aimed to equip students with essential knowledge about organic waste and the eco-enzyme fermentation process. Activities sought to foster positive environmental attitudes and increase student involvement in sustainable practices. The program intended to transform waste awareness into actionable, repeatable behavior within the school and local community. The community service initiative created a platform for behavioral change and practical environmental learning among vocational students. The program empowered young people to become advocates of zero-waste strategies, while supporting the broader goals of organic farming and sustainability. Students gained tangible experience that reinforced both academic learning and community responsibility through innovative waste management practices.

2. METHOD

The community service program employed a participatory and experiential learning approach, designed to actively engage students throughout the process. The method combined informative sessions, group discussions, hands-on practice, and interactive feedback to maximize student engagement and retention of knowledge. The program targeted tenth-grade students from the Integrated Agricultural Business Department at SMK Negeri 2 Sukoharjo.

The team structured the activities into three key stages: preparation, implementation, and evaluation. The preparation stage involved curating instructional materials, developing visual aids, and securing the tools and ingredients necessary for eco-enzyme production. The team also coordinated with school staff to arrange schedules, access to classrooms, and student participation. The implementation phase began with an introductory lecture that explained organic waste and the eco-enzyme process, presented via a PowerPoint presentation. The session proceeded with a live demonstration of how to produce eco-enzymes using fruit and vegetable scraps, water, and brown sugar in the recommended ratio. Students participated directly in the process by preparing the ingredients, mixing the materials, and labeling the fermentation containers. The final evaluation phase assessed student participation and understanding through guided discussions and observation. The team recorded verbal feedback and reactions from the participants to gauge the depth of learning and practical interest. This structured method enabled the students to learn through doing, which enhanced their ability to retain concepts and apply eco-enzyme techniques in everyday life.

Community Service Location and Participants

The community service was conducted at SMK Negeri 2 Sukoharjo, a vocational high school focused on agriculture, located in Central Java, Indonesia. A total of 36 students from the tenth grade of the Integrated Agricultural Business (UPT) program participated in the activity. These students represented the primary target group due to their academic relevance and potential for applying sustainable practices. The school's staff and administrators played a key role in facilitating the program by coordinating logistics and supporting student engagement throughout the eco-enzyme education activities.

Detailed Stages of Activity Implementation

The implementation of community service activities followed a structured three-stage process: preparation, execution, and evaluation. The preparation stage involved designing educational materials, preparing demonstration tools, and coordinating with school administrators to ensure student participation and engagement. The team selected visual slides, eco-enzyme samples, and fermentation equipment to support both theoretical and practical components of the learning process.

The execution stage began with an engaging presentation that introduced the problems associated with organic waste and the benefits of eco-enzyme production. The team delivered the content using interactive slides to promote student understanding. Following the presentation, students participated in a guided demonstration where they prepared eco-enzyme mixtures using fruit and vegetable scraps, brown sugar, and water in a 3:1:10 ratio (Manalu et al., 2024). Each group labeled their mixture and discussed fermentation time, storage methods, and possible applications.

The evaluation stage focused on observing student responses, practical involvement, and feedback during the sessions. The team assessed student understanding through verbal interactions and questions during the demonstration. Students expressed interest and curiosity about the benefits and potential uses of eco-enzymes in agriculture and daily cleaning practices. This phase highlighted the effectiveness of the hands-on approach in reinforcing the presented concepts and building practical awareness.

Community Service Impact Analysis Method

The team employed a quantitative evaluation method to assess the effectiveness of community service activities on student learning outcomes. The approach aimed to identify significant changes in student understanding and behavior before and after the eco-enzyme education program. A structured questionnaire using a five-point Likert scale was administered to measure changes across key evaluation indicators (Norman, 2010).

The impact analysis consisted of three stages: **pre-assessment**, **intervention**, and **post-assessment**. The pre-assessment captured baseline data on students' knowledge of organic waste, eco-enzyme concepts, practical readiness, and sustainability attitudes. The intervention phase included educational delivery through presentations, demonstrations, and direct student involvement in eco-enzyme production. The post-assessment repeated the same questionnaire to measure changes after the intervention (Bell et al., 2017).

The analytical hypothesis for the study was formulated as follows:

a. **H_0 (Null Hypothesis)**: There is no significant difference in student knowledge and attitudes before and after the intervention.
b. **H_1 (Alternative Hypothesis)**: There is a significant difference in student knowledge and attitudes before and after the intervention.

To test this hypothesis, the team used the **Mann–Whitney U test**, a non-parametric statistical method suitable for comparing two independent samples without assuming a

normal distribution. This test assessed the differences in median scores between the pre-test and post-test for each evaluation indicator. The significance level (α) was set at 0.05, which guided the decision to accept or reject the null hypothesis.

The Table 1 below presents the **evaluation indicators** and analysis framework used to measure student outcomes (Puspa & Sudibya, 2016):

Table 1. Measurement instrument for pre- and post-community service evaluation

Evaluation Indicator	Measurement Method	Data Source	Analysis Tool
Knowledge of organic waste	Likert scale (1–5)	Pre-test and post-test	Mann–Whitney U test
Understanding of the eco-enzyme concept	Likert scale (1–5)	Pre-test and post-test	Mann–Whitney U test
Practical readiness	Likert scale (1–5)	Pre-test and post-test	Mann–Whitney U test
Attitude toward sustainability	Likert scale (1–5)	Pre-test and post-test	Mann–Whitney U test
Willingness to apply eco-enzymes	Likert scale (1–5)	Pre-test and post-test	Mann–Whitney U test

This analytical model not only validated the direct impact of the program but also provided an evidence-based foundation for crafting broader intervention strategies. When statistically significant changes are observed, education stakeholders—including vocational school administrators and local government—can consider integrating eco-enzyme modules into standard agricultural curricula. Institutions may also establish partnerships with waste management authorities to facilitate student-led sustainability initiatives.

Data generated from this model supports the formulation of localized policy recommendations, such as developing student-community waste reduction programs or embedding eco-enzyme production into agribusiness skill assessments. Moreover, the methodology enables replication in other schools with similar profiles, ensuring scalability and institutional learning. By aligning community service outcomes with measurable behavioral shifts, this approach provides a practical pathway for transforming short-term educational interventions into lasting environmental policy impacts.

3. RESULTS AND DISCUSSION

The impact of eco-enzyme education on student learning was assessed through a pre- and post-intervention evaluation involving vocational agriculture students. The purpose was to determine whether the structured community service activities led to measurable improvements in knowledge, attitudes, and behavioral readiness related to organic waste management. Table 2 shows data collected using a Likert scale questionnaire and analyzed with the Mann–Whitney U test to determine statistical significance across five learning indicators. This evaluation serves as the foundation for assessing program effectiveness and potential scalability for future sustainability-focused interventions.

Table 2. The Mann–Whitney U test results

Indicator	Mann–Whitney U	Z Score	Asymp. Sig. (2-tailed)	Interpretation
Knowledge of Organic Waste	230.000	-3.121	0.002	Significant improvement
Understanding of the Eco-Enzyme Concept	215.500	-3.432	0.001	Significant improvement
Practical Readiness	267.000	-2.201	0.028	Moderate improvement

Attitude Toward Sustainability	205.000	-3.582	0.000	Strong positive shift
Willingness to Apply Eco-Enzymes	198.500	-3.765	0.000	Strong positive shift

The test results revealed statistically significant improvements across all measured indicators following the eco-enzyme education intervention. The most notable gains appeared in students' understanding of eco-enzyme concepts and their willingness to apply them in daily life, with p-values below 0.001. These outcomes suggest that the experiential, hands-on teaching approach successfully bridged cognitive and behavioral gaps among students, making abstract sustainability principles more tangible and actionable.

The moderate improvement in practical readiness may reflect the short intervention duration, which, while effective for concept introduction, offered limited time for repeated practice and deep procedural learning. The moderate score of practical competence because individuals who have a high level of practical competence will try not to participate in activities that have negative impacts on the environment. Moreover, they will invite people in their surroundings to perform environmentally friendly life habits. Low practical competence can be caused by the knowledge possessed has not been fully implemented or following the behaviour of others who do not care about the environment (Nurfajriani et al., 2018). Nonetheless, the shift from passive awareness to proactive behavior—indicated by the significant changes in attitude and willingness—demonstrates the intervention's success in initiating long-term behavioral change pathways. The Mann–Whitney U test confirmed that student responses were not due to chance, affirming the intervention's capacity to create measurable learning gains.

Two previous studies offered differing conclusions regarding the immediate impact of short-term environmental education. First, Sigit et al., (2023) argued that eco-literacy programs in schools have a medium impact on student behavior without long-term reinforcement. Second, Huda & Rajagukguk, (2020); Homaidy & Aulia, (2023), found no measurable difference in sustainable attitudes among vocational students exposed to a single workshop on waste management. These contrasting findings highlight the importance of not only instructional design but also learner context and subject relevance when evaluating program outcomes. The integration of waste management principles is essential for developing a comprehensive character education curriculum across all educational stages. Institutions are responsible for implementing organized and environmentally sound waste management practices. Furthermore, a concerted effort is required at each educational level to provide students with instruction on effective waste management. Based on their learning experiences, seeing and directly interacting with the school and its surrounding environment, environmentally conscious habits can form a character that is inherent in students

The test results support the Constructivist Learning Theory, which posits that learners construct knowledge through hands-on experiences and active engagement. By involving students in the direct creation of eco-enzymes, the program allowed learners to contextualize abstract environmental concepts into real-world practices. The data support the theory that authentic tasks enhance cognitive retention and motivate behavioral adoption, particularly when educational content aligns with students' daily environments and future vocational paths.

During implementation, students demonstrated enthusiasm and curiosity, often asking detailed questions about fermentation time, usage methods, and potential benefits in agriculture. The atmosphere remained interactive throughout the sessions, and students voluntarily shared reflections on the importance of managing kitchen waste at home. School administrators observed heightened participation and recommended including similar

workshops in other agricultural units—these behavioral indicators aligned with post-test data, supporting the statistical results with observable field behavior.

Figure 1. Introduction to eco-enzyme materials

Figure 2. Practice to make eco-enzyme

The results suggest that integrating sustainability topics within vocational training not only enhances knowledge but also nurtures environmental responsibility. Educational strategies that combine lectures, demonstrations, and hands-on applications are essential in translating classroom awareness into behavioral readiness. Behavioral readiness can also be acquired through direct learning and observation of others (Matanari, 2020). To cultivate pro-environmental behaviors in students, the principles of environmental education can be internalized and integrated into a school's core learning activities (Martha & Mahanani, 2020). Therefore, the program serves as a practical model for schools aiming to promote eco-literacy and community impact simultaneously.

Schools, particularly those in agricultural education, can adopt eco-enzyme projects as recurring learning activities. Curriculum designers should consider embedding similar modules into formal education to strengthen waste reduction practices and develop sustainability-oriented skill sets. In turn, this could influence student behavior in both academic settings and their broader communities. The school environment is a formal educational institution that systematically plans various educational environments that provide opportunities for students to engage in a variety of learning activities. Thus, education can take place not only in the classroom but also by utilizing the surrounding environment through the implementation of an environment-based curriculum in the learning process (Muslih, 2016; Widiantoro & Minsih, 2023).

Figure 3. Community service programs participants

4. CONCLUSION

The community service program successfully fulfilled its primary objective: equipping vocational agriculture students with essential knowledge about organic waste and the eco-enzyme fermentation process. The post-intervention evaluation revealed significant improvements in students' understanding, attitudes, and willingness to apply eco-enzyme practices in real life. These outcomes confirm that experiential, hands-on education remains a powerful tool for shaping sustainable behavior, especially when delivered in a structured, relatable, and participatory format. The Mann–Whitney U test validated the learning impact, yielding statistically significant results across all indicators, which supports the conclusion that the intervention was effective. Field observations further strengthened this finding. Students not only actively engaged in the sessions but also demonstrated genuine interest by asking questions, participating in fermentation activities, and reflecting on waste issues from both personal and agricultural perspectives. The enthusiasm observed suggests the program resonated beyond academic interest—it sparked awareness and a sense of environmental responsibility. Based on these findings, it is recommended that vocational schools integrate eco-enzyme education into their regular curricula, especially within agriculture and environmental science units. Policy stakeholders should support the inclusion of sustainability modules that combine knowledge delivery with direct practice. Schools can also collaborate with local waste management agencies or farming communities to establish student-led initiatives that convert waste into products. Such efforts would institutionalize environmental education, enabling long-term behavior change and community impact. Expanding the program to other schools with similar profiles can accelerate the development of eco-literate youth who actively participate in environmental preservation. As the urgency to manage household waste intensifies, empowering the younger generation with actionable, science-based solutions, such as eco-enzymes, is not only relevant—it is imperative for a sustainable future.

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