

PEPS-KL: An Ecoliteracy Intervention for Plastic Waste Management Education

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Abstract

This community service program aims to enhance the ecoliteracy of high school students in plastic waste management through the *Program Edukasi Pengelolaan Sampah Plastik untuk Keberlanjutan Lingkungan* (PEPS-KL) at SMAN 1 Takalar, Takalar Regency, South Sulawesi. The program was developed using the Community-Based Participatory Research (CBPR) method, incorporating the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) with an experiential learning approach. Participants comprised 35 tenth-grade students who participated in an intensive 6-hour learning program. Evaluation was conducted using a one-group pretest-posttest design with quantitative analysis through the Wilcoxon Signed Ranks Test and qualitative analysis through content analysis of participants' reflections. The program successfully improved participants' knowledge significantly ($Z = -5.067$, $p < 0.001$) with an average score increase of 55.01% from pretest ($M = 6.69$) to posttest ($M = 10.37$). A total of 94.3% of participants experienced improved understanding of ecoliteracy. Qualitative evaluation revealed participants' holistic transformation encompassing critical awareness of microplastic impacts, intrinsic motivation for change, positive emotional responses, construction of new knowledge, and commitment to becoming agents of environmental change. PEPS-KL proved effective in facilitating holistic learning that encompasses the cognitive, affective, and conative domains, which are essential to developing effective and sustainable environmental education strategies at the high school level.

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INTRODUCTION

In the modern era, daily human activities generate various types of waste, with plastic waste emerging as a significant global environmental challenge that requires serious attention. The exponential increase in plastic waste volumes is driven by society's dependence on single-use plastic products, while plastic's non-biodegradable

characteristics make waste management increasingly complex ([Evode et al., 2021](#)). This problem becomes particularly critical when associated with modern consumption patterns that prioritize convenience over environmental sustainability.

This global challenge is particularly critical in Indonesia, which ranks second worldwide as the most significant contributor to plastic pollution after China, generating 3.2 million tons of unmanaged plastic waste annually, with approximately 1.29 million tons ending up in the ocean. Indonesia also ranks highest globally in terms of microplastic consumption. At the same time, the country's ineffective plastic waste management system exacerbates the situation as most plastic waste is not collected correctly and ends up mixed in landfills without adequate sorting ([International Pollutants Elimination Network, 2024](#); [Jambeck et al., 2015](#); [Ministry of Environment and Forestry, 2020](#); [Rajamani & Lim, 2024](#); [Widyastuti et al., 2021](#)). These national challenges create a cascading effect that impacts local communities, particularly in environmentally vulnerable areas where adequate waste management infrastructure is limited.

These national challenges extend to local contexts, particularly in coastal regions such as Takalar Regency in South Sulawesi Province, which faces heightened vulnerability to plastic waste pollution due to its geographic location. At SMA 1 Takalar, situational analysis through direct observation, interviews with school officials, and baseline knowledge assessment (n=50) revealed three main categories of challenges, such as knowledge gaps (where baseline assessment showed that 86% of students (43 out of 50) achieved scores below 60 out of 100, specifically showing low understanding of proper plastic waste management and environmental impacts, as well as minimal knowledge of waste processing into valuable products), behavioral issues (lack of awareness for appropriate waste disposal despite adequate facilities, excessive plastic consumption without environmental consideration), and institutional limitations (absence of systematic and comprehensive environmental education programs). These conditions create an uncondusive school environment with scattered waste and non-pro-environmental behavior patterns among students, contradicting efforts to develop a generation with character and environmental consciousness.

Addressing this complexity requires strategic efforts through comprehensive approaches involving school-level education as a long-term investment to create an environmentally conscious generation, with ecoliteracy serving as the essential foundation. Ecoliteracy, defined as a comprehensive understanding of the ecological system, the impact of human activities on the environment, and the ability to take responsible action, becomes key in forming an environmentally conscious generation by focusing not only on knowledge transfer but also on developing critical thinking abilities and responsible decision-making regarding complex environmental issues ([Rahmat et al., 2025](#); [Shutaleva, 2023a](#)). Research demonstrates that ecoliteracy-based environmental education interventions significantly impact environmental awareness and pro-environmental behavior, with meta-analysis studies showing substantial improvements in adolescents' knowledge, attitudes, and pro-environmental behavior ([Kalaycı & Korutürk, 2024](#); [van de Wetering et al., 2022](#)).

Senior High School (SMA) students are an optimal target for environmental education interventions because of their cognitive readiness at the formal operational stage, which enables them to understand complex cause-and-effect relationships and integrate information from various sources to comprehend environmental issues holistically. Additionally, adolescents at this stage of development begin to form their social identity. They can become agents of change in their communities, making them ideal candidates for environmental education programs that aim to create lasting behavioral changes ([Branje et al., 2021](#); [Malik & Marwaha, 2023](#)).

Based on these considerations, *Program Edukasi Pengelolaan Sampah Plastik untuk Keberlanjutan Lingkungan* (PEPS-KL) was developed as a scalable, school-based ecoliteracy intervention designed to equip students with comprehensive knowledge, practical skills, and pro-environmental behaviors to address plastic waste issues. The program aims to increase students' knowledge and awareness of the environmental and health impacts of plastic waste, develop practical skills in plastic waste management and processing, foster sustainable pro-environmental attitudes and behaviors, create agents of change at the school level, and provide a program model adaptable for other schools. Through implementing this program, students are expected to develop into agents of change capable of executing creative plastic waste management actions and spreading pro-environmental awareness in their communities, thus contributing to efforts to mitigate the plastic waste crisis in their surrounding environment.

METHODS

The PEPS-KL community service program was implemented at SMAN 1 Takalar, Takalar Regency, South Sulawesi Province, on May 28, 2022, from 09.00 to 15.00 WITA. This location was selected based on the needs analysis results, which indicated specific problems related to plastic waste management at the school, and the school's commitment to actively participating in the service program.

Program participants consisted of 35 tenth-grade students aged 15-16 years selected based on the following criteria: tenth-grade students in their first year of senior high school education, commitment to participate in the entire series of activities, and willingness to become agents of change in the school environment. The tenth-grade students were selected based on their potential as agents of change who could inspire other students in creating an environmentally conscious school ecosystem.

PEPS-KL was developed using the Community-Based Participatory Research (CBPR) method, incorporating the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) with an experiential learning approach. CBPR is a community-based research approach that aims to effect social change by positioning students as equal partners rather than passive subjects throughout the research process ([Duke, 2020](#); [Fauzi et al., 2023](#)). CBPR, ADDIE, and experiential learning were combined through participatory activities at each stage. In the Analysis, students jointly identified problems. In Design, they joined planning sessions to help develop materials and methods. In Development, students' feedback shaped modules and evaluation tools. In Implementation, students acted as co-facilitators. For Evaluation, they helped analyze results and plan sustainability efforts. This methodological integration created a community-centered framework where students served as co-researchers in problem identification, collaborative designers of learning materials, active facilitators during implementation, and partners in program evaluation, enabling students to become environmental change agents within their community ([Hacker, 2017](#); [Jauharul et al., 2021](#); [Pebrianti et al., 2024](#)). The synthesis of CBPR, ADDIE, and experiential learning principles ensured that the program was simultaneously systematic, participatory, and transformative, ultimately developing both individual ecoliteracy and collective capacity for sustainable environmental stewardship ([Janeusse et al., 2025](#); [Yunindyawati et al., 2024](#)).

The implementation of the ADDIE model for the PEPS-KL program follows a systematic, sequential process, as illustrated in Table 1 and Figure 1. Each phase builds upon the previous one, ensuring comprehensive program development and evaluation.

Table 1 CBPR-aligned ADDIE model activities for PEPS-KL program

Phase/ Stage	Form of Activity
Analysis	• Conduct participatory needs assessments through direct observation of school environment conditions with student involvement. • Engage in interviews with school stakeholders, including the principal, teachers, and students, to collaboratively identify specific needs. • Analyze student characteristics and co-establish program objectives with participants.
Design	• Co-design a learning approach using experiential learning with student input. • Collaboratively develop educational materials covering five ecoliteracy components: plastic waste statistics, plastic degradation processes, microplastic impacts on health and environment, alternative solutions for plastic waste reduction, and proper waste management procedures. • Plan integrated learning methods through collaborative sessions, including interactive lectures, reflection, collaborative learning, and practical demonstrations. • Co-develop implementation stages following the experiential learning structure: introduction, activity, debriefing, and summary.
Development	• Collaboratively develop PEPS-KL modules that address partner requirements, incorporating feedback from students. • Develop evaluation instruments, including pretest and posttest questionnaires, to assess module effectiveness. • Validate materials through expert review by lecturers with environmental psychology expertise, pro-environmental practitioners, and trainers, in collaboration with participants.
Implementation	• Facilitate the program in collaboration with students, who serve as co-facilitators according to the established program design. • Monitor and document the activity process with active participant involvement. • Conduct process evaluation during program implementation, integrating student input.
Evaluation	• Facilitate joint reflection on program effectiveness by conducting pretest and posttest analyses with students. • Analyze student reflections collaboratively to assess cognitive and affective changes. • Co-evaluate program sustainability and develop follow-up action plans with students.

Figure 1 provides a visual representation of the sequential ADDIE model, highlighting the interconnected activities within each phase and the overall program flow from initial analysis to final evaluation.



Figure 1 The sequential ADDIE model

RESULTS AND DISCUSSION

PEPS-KL was developed and implemented using the ADDIE model as a systematic framework to ensure program quality and effectiveness. The following presents the results and discussion of each ADDIE phase in the PEPS-KL implementation.

Analysis Phase

The analysis phase revealed fundamental problems related to low ecoliteracy levels in plastic waste management at SMAN 1 Takalar. Field observations showed student behaviours that did not reflect ecoliteracy understanding, namely, carelessly disposing of plastic waste despite adequate waste disposal facilities being available, and excessive plastic consumption patterns (as shown in Figure 2). Interview results with school stakeholders reinforced findings that students had not yet developed pro-environmental awareness and that their understanding of environmentally friendly waste management principles remained limited. This aligns with research by [Kibria et al. \(2023\)](#), which states that a lack of pro-environmental awareness is a significant factor in the massive accumulation of plastic waste.



Figure 2 Improperly disposed plastic waste in educational settings

These field findings indicate a significant gap, where students have not yet developed sufficient environmental awareness to behave pro-environmentally and have a limited understanding of sustainable plastic waste management practices. From these findings, four main points of needs analysis were formulated: (1) strengthening environmental literacy through providing education to build students' understanding of pro-environmental behavior and sustainable waste management practices, (2) developing ecological awareness regarding the negative impacts of plastic pollution on human health and ecosystems to form responsible attitudes toward the environment, (3) improving practical ecoliteracy competence through learning about effective and environmentally friendly waste management techniques and strategies, and (4) implementing project-based environmental learning to develop skills in processing plastic waste into valuable products. Research shows that environmental education can increase awareness and commitment to solving local environmental problems ([Liu et al., 2023](#)). These analysis results became the foundation for designing a targeted program that matches partners' specific needs.

Another analysis conducted was determining intervention participants. The designation of tenth-grade students as intervention participants was based on several considerations. First, interview results with school stakeholders indicated that tenth-grade students, as first-year students in their capacity as new members of the school, have the potential to become agents of change toward creating an environmentally conscious school ecosystem and can inspire students from other grade levels. Second, field observations showed that many tenth-grade students have urgent needs for developing

pro-environmental behavior, given their behaviors that do not yet reflect environmental awareness, such as littering and excessive plastic use. Third, the cognitive development stage of tenth-grade students is in the formal operational phase, making it optimal for absorbing environmental knowledge and developing sustainable pro-environmental attitudes.

In addition, general and specific objectives were established in this phase. This program aims to improve understanding, awareness, and skills in sustainable plastic waste management so that students can behave pro-environmentally and become agents of change in realizing an environmentally friendly school environment. Specific objectives were designed using Bloom's taxonomy: building understanding of ecological systems, plastic pollution impacts, and principles of sustainable waste management (cognitive domain); fostering environmental awareness, responsible attitudes toward the environment, and concern for the impact of individual actions on ecosystems (affective domain); and developing practical skills in waste management, recycling techniques, and the ability to create innovative solutions for environmental problems (psychomotor domain).

Design Phase

At this stage, the intervention program model approach used was determined to be experiential learning. Experiential learning is learning based on individual experience, in which individuals learn from experience or through experience (Kolb, 2015). This approach was chosen because it can facilitate meaningful learning through active student involvement in the learning process. This intervention program includes three integrated components: activity-based, reflective, and collaborative learning. Combining these three components can produce optimal learning outcomes (Kuo et al., 2024).

Learning materials were designed according to the specific objectives formulated in the analysis stage, encompassing five main components: (1) global and national plastic waste statistical data to provide an overview of the problem's scale, (2) plastic waste degradation processes for systemic understanding of environmental impacts, (3) microplastic impacts on health and the environment to build personal awareness, (4) alternative solutions for plastic waste reduction to develop problem-solving abilities, and (5) proper waste management procedures to equip practical skills. Each material component was designed to emphasize the importance of sustainable plastic waste management.

Learning methods were designed using a combination of interactive lectures, reflection, and practical demonstrations. Interactive lectures were chosen to transfer factual knowledge by engaging students through questions and brief discussions. Reflection was designed to facilitate internalization of pro-environmental values. Practical demonstrations were designed to develop applied skills. The integration of these methods refers to the experiential learning cycle that includes four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation.

Development Phase

Program modules and evaluation instruments were developed in the development stage. The intervention program module developed was named "*Program Edukasi Pengelolaan Sampah Plastik untuk Keberlanjutan Lingkungan*" or PEPS-KL. It was developed based on results from the design stage.

Module validation was conducted through expert judgment involving three qualified validators with at least five years of experience in their respective fields: an Environmental Psychology lecturer, a pro-environmental practitioner, and an experienced

trainer. Validation was performed using assessment rubrics that included content relevance, appropriateness of materials and methods, suitability to target characteristics, and implementation feasibility. Validation results showed excellent content validity, with an average score of 4.75 on a 5.0 scale, indicating high content validity. Nevertheless, there was constructive feedback from validators, including language adjustments to align with high school students' cognitive development, the addition of local case studies to enhance contextual relevance, and optimisation of time allocation for each learning session to improve effectiveness. Based on validator feedback, revisions were made to produce a final module that was ready for implementation.

The evaluation instrument was developed as pretest and posttest questionnaires consisting of 15 multiple-choice questions adapted to the material to be provided. Each question was adapted using Bloom's taxonomy to ensure appropriate difficulty gradation for high school students' cognitive abilities. The pretest-posttest design is a commonly used and effective method for measuring changes in behavioural intervention research, although it has certain methodological limitations that need to be considered ([Alessandri et al., 2017](#)). The development of valid and reliable instruments becomes key in measuring program effectiveness.

Implementation Phase

PEPS-KL was implemented with 35 tenth-grade students at SMAN 1 Takalar for 6 hours of learning (09.00-15.00 WITA). The program was implemented following the experiential learning structure consisting of four main stages: introduction, activity, debriefing, and summary.

- a. The introduction stage (50 minutes) began with an opening session and learning contract for 20 minutes to build rapport with students, convey learning objectives, and establish ground rules to create a conducive learning environment. This was followed by a pretest for 15 minutes in the form of 15 multiple-choice questions to determine the extent of students' understanding regarding global and national plastic waste statistical data, plastic waste degradation processes, microplastic impacts on health and the environment, alternative solutions for plastic waste reduction, and proper waste management procedures before conducting activities. This stage concluded with 15 minutes of icebreaking, which included simple games to create a conducive atmosphere and build initial motivation to participate in the intervention program.
- b. The activity stage (210 minutes) constituted the program's core, consisting of two main activities. The first activity was a 90-minute interactive lecture that transferred knowledge about global and national plastic waste statistical data, plastic waste degradation processes, microplastic impacts on health and the environment, alternative solutions for plastic waste reduction, and proper waste management procedures through lecture methods involving students through questions and brief discussions (as shown in Figure 3).



Figure 3 Activity: Interactive lectures

The second activity was *Diskusi dan Olah Sampah* (DOS), a 120-minute practical demonstration through collaborative learning in 4 groups, in which participants processed plastic waste into creative products. Each group conducted a field exploration to collect plastic waste in the school area as raw material for creating creative products. The discussion focused on upcycling plastic waste into valuable products by applying waste management principles learned. The activity concluded with the presentation of work results and peer evaluation sessions to determine the best product.

- c. The debriefing stage (30 minutes) focused on a reflection sharing session where students shared their experiences, including feelings during the activities, insights gained, and next steps to be taken after participating in the entire activity process.
- d. The summary stage (35 minutes) consisted of three closing activities. It began with a 15-minute wrap-up to summarize the learning and facilitate commitment to sustainable actions post-program. This was followed by a 15-minute posttest, in which students were given multiple-choice questions identical to the pretest, to assess the extent of student change after completing the series of intervention program activities. The program concluded with a 5-minute closing and reward-giving to provide positive reinforcement through awards to the best group and active students. It also delivered take-home messages in the form of concrete commitments to become agents of change in plastic waste management in their respective schools or individual environments.

Evaluation Phase

The evaluation phase constitutes the final stage aimed at evaluating the effectiveness of PEPS-KL. The evaluation used a one-group pretest-posttest design, comparing scores before and after PEPS-KL implementation, and was complemented by a qualitative evaluation of student reflections from the debriefing session.

Evaluation results showed significant improvement in students' knowledge of ecoliteracy, including global and national plastic waste statistics, plastic waste degradation processes, microplastic impacts on health and the environment, alternative solutions for plastic waste reduction, and proper waste management procedures. The average pretest score of 6.69 increased to 10.37 on the posttest, showing an improvement of 55.01 percent (see Table 2).

Table 2 Comparison of pretest and posttest scores

Aspect	Pretest	Posttest	Improvement
Mean	6.69	10.37	3.68 (55.01%)
Median	7.00	11.00	4.00
Std. Deviation	1.97	1.57	-0.40
Minimum	3.00	6.0	3.00
Maximum	10.00	13.00	3.00

The Wilcoxon Signed Ranks Test results showed a highly significant difference ($Z = -5.067$, $p < 0.001$) between scores before and after the program. As many as 94.3 per cent of participants experienced score improvements, indicating program effectiveness. The decrease in standard deviation from 1.97 to 1.57 indicates that the program increased average scores and reduced variability among students, demonstrating uniform program effectiveness.

This quantitative improvement aligns with the qualitative results observed in student reflections. The 55.01% increase in knowledge about global and national plastic waste statistics was reflected in students' understanding that "humans have indirectly consumed plastic waste through food and beverages," demonstrating the program's success in

building systemic understanding of the relationship between waste management and personal health. This indicates the emergence of critical awareness among students about the impacts of microplastics. Students' expressions of "feeling happy to receive new information about the importance of plastic waste processing" demonstrate the formation of intrinsic motivation, essential for the sustainability of behavioral change. Furthermore, students' commitment to becoming "environmental change agents by reducing plastic use," as reflected in student reflections, shows deep internalization of pro-environmental values, supported by formal knowledge enhancement.

Compared to the meta-analysis conducted by van [de Wetering et al. \(2022\)](#), which examined 169 studies from 43 countries and demonstrated an average improvement in environmental knowledge, PEPS-KL achieved a 55.01% improvement, representing a highly significant enhancement. The Earthkeepers program in Arizona ([Baierl et al., 2022](#)), which employed a 3-day outdoor education approach and positioned participants as passive program recipients, produced significant improvements. However, PEPS-KL demonstrates superiority by implementing a triple-layered methodology (CBPR + ADDIE + Experiential Learning) that positions students as active participants in the learning process. [Rau et al., \(2022\)](#) found in their systematic review that most pro-environmental behavior change interventions only produce minor positive effects, while PEPS-KL, by combining education strategies, hands-on learning, and direct application, creates a "real waste, real impact" model through the "DOS" approach that transforms actual waste materials into valuable products, generating superior effectiveness.

PEPS-KL's success can be attributed to three mutually reinforcing factors. First, the systematic ADDIE framework ensures structured program development aligned with partner needs, consistent with research demonstrating the effectiveness of ADDIE in producing high-quality programs ([Aldoobie, 2015](#); [Spatioti et al., 2022](#)). Second, the integrated experiential learning approach, which combines activity-based, reflective, and collaborative learning, enables students to understand concepts and apply them to tangible products, consistent with research showing that experiential learning effectively bridges the gap between classroom learning and real-world application ([Shutaleva, 2023b](#)). Third, the innovative "DOS" model transforms school plastic waste into creative products within one day, creating tangible results that distinguish PEPS-KL from other ecoliteracy programs focused on theoretical knowledge transfer.

Program scalability is reflected in the adaptability of a modular framework for various environmental issues, the replication of the DOS model with different local materials, and transferability across diverse educational contexts. With its high sustainability potential and multiplier effects that reach broader communities, PEPS-KL positions itself as an innovative model. This is supported by research showing that combined strategy interventions are more effective in producing sustainable pro-environmental behavioral changes ([Rau et al., 2022](#)).

CONCLUSION

PEPS-KL, developed using the ADDIE model with an experiential learning approach, proved effective in enhancing the ecoliteracy of tenth-grade students at SMAN 1 Takalar. Quantitative evaluation results provide strong empirical evidence of the program's effectiveness, with highly significant improvements in ecoliteracy scores, and nearly all students experienced substantial progress in understanding after participating in the intervention program. Qualitative data reinforced the quantitative findings by revealing learning dimensions encompassing attitudinal changes, the formation of critical awareness, and students' transformative commitment to becoming agents of environmental change. The combination of positive emotional responses, new knowledge

construction, mastery of practical skills, and behavioral commitment demonstrates that the program successfully facilitated holistic learning encompassing cognitive, affective, and conative domains.

Future research recommendations include longitudinal studies to examine the sustainability of long-term behavioral change, comparative studies with control groups to strengthen causal inference, and community impact studies to assess the effects of student change agents. These findings contribute to the development of effective and sustainable environmental education strategies at the senior high school level, providing a foundation for expanding evidence-based ecoliteracy interventions.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

The authors' contributions to this community service article include SMMM, NDUJ, and NIA, who conceptualized and designed the methodology; NDUJ and NIA, who collected the field data; SMMM, who analyzed the data; and SMMM and MAM, who prepared the original draft manuscript.

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