

# Building Environmental Literacy: A Green Literacy Bootcamp Model for an Eco-School within a Coastal Community

Rizki Nor Amelia<sup>1\*</sup>, Sri Ngabekti<sup>2</sup>, Putri Alifa Kholil<sup>3</sup>, Abdul Jabbar<sup>4</sup>, Prasetyo Listiaji<sup>5</sup>

<sup>1</sup>Science Education Study Program, Universitas Negeri Semarang, Indonesia

<sup>2-4</sup>Environmental Science Study Program, Universitas Negeri Semarang, Indonesia

<sup>5</sup>Doctoral School of Education, University of Szeged, Hungary

## ABSTRACT

Coastal schools are highly vulnerable to the impacts of climate change, including tidal flooding, erosion, and seawater intrusion, which disrupt educational processes and compromise community resilience. Strengthening environmental literacy within the eco-school framework is therefore essential to develop adaptive knowledge, critical thinking, and sustainable behavior among students. This community service project implemented a *Green Literacy Bootcamp* at SMP Negeri 25 Semarang, involving 45 students identified as prospective Green Warriors. The program comprised three phases: a two-day intensive training, a three-month follow-up, and a final reflection. Activities included communication workshops, creative campaigns, eco-project simulations, and student-led projects on waste management, urban farming, and tidal flood mitigation. The program was evaluated using a pre-post environmental literacy test and structural model analysis, complemented by a satisfaction survey. Results showed a substantial improvement in environmental literacy, with the most significant gains observed in environmental hope and cognitive skills. Students also reported high satisfaction with the learning experience. This study contributes to the field of environmental education by offering a validated and replicable model for strengthening multidimensional environmental literacy and supporting eco-school development in coastal communities facing climate change challenges.

**Recommended citation:** Amelia, R.N., Ngabekti, S., Kholil, P.A., Jabbar, A., & Listiaji, P. (2025). Building Environmental Literacy: A Green Literacy Bootcamp Model for an Eco-School within a Coastal Community. *Jurnal Pemberdayaan Masyarakat*, 4(4), 856-868.

## ARTICLE INFORMATION

### Keywords:

adhiyaya; coastal schools; environmental literacy; green literacy bootcamp

### \*Correspondent Author:

Rizki Nor Amelia

### Email:

rizkinoramelia@mail.unnes.ac.id

## INTRODUCTION

Coastal areas are ecosystems that are highly vulnerable to the impacts of climate change, such as tidal flooding, abrasion, and seawater intrusion, which have direct implications for social life and education in these areas. Schools located in coastal areas face a double challenge: providing quality education while equipping students with skills for environmental adaptation and mitigation. This challenge is further complicated by the fact that coastal schools not only face limited educational resources but also natural conditions that are prone to disasters, requiring a contextual curriculum that integrates mitigation and adaptation into learning (Yuliani et al., 2024; Katmie, 2023; Podungge & Solihin, 2023). In this context, environmental literacy is no longer seen as merely an additional skill, but rather a fundamental requirement for shaping a generation that is resilient to environmental change. Several studies confirm that literacy-based environmental education can improve students' critical thinking skills, foster hope, and strengthen commitment to pro-environmental action, while a purely cognitive approach has proven to be less effective in driving real change (Iwaniec, 2020; Liu et al., 2020). However, although the international literature has proven the effectiveness of environmental education, studies with a local context, particularly in Indonesian coastal schools,

remain very limited. This research gap presents an important opportunity for developing more contextually relevant intervention models that can effectively address specific needs while enhancing national policies in the field of environmental education.

In response to these needs, empirical evidence suggests the need for a multimodal learning approach that integrates applied simulations, school-based projects, and periodic follow-ups to strengthen knowledge, change attitudes, and modify behavior. Longitudinal evaluations demonstrate that the effects of environmental education programs are most sustainable when interventions incorporate repeated field experiences, contextual learning, and institutional support that ensures sustainability (Collado et al., 2022; Pan & Hsu, 2022). Furthermore, various studies confirm that the success of environmental education is also greatly influenced by a supportive institutional climate and integration into school policy, because without this foundation, interventions tend to be short-term and difficult to sustain (Mochizuki & Bryan, 2015; Pe'er et al., 2007). Therefore, environmental literacy interventions in coastal schools should be designed systematically, with multidimensional measurements (i.e., cognitive, affective, and behavioral aspects) serving as the primary benchmarks. This approach enables the creation of a more comprehensive evaluation framework, allowing program outcomes to measure not only knowledge improvement but also changes in students' affective dispositions and actual behavior. Furthermore, strengthening environmental capacity in coastal schools through the use of appropriate evaluation instruments can provide empirical evidence that enriches the basis for environmental education policy in Indonesia, while also enhancing the program's legitimacy at the global level.

In Indonesia, the Adiwiyata program has become a national framework for promoting *eco-schools* by integrating environmental education into the curriculum, school culture, and community participation. As a systematic effort, this program is designed to create environmentally friendly schools with character by emphasizing four main components: environmentally conscious policies, the implementation of an environmentally based curriculum, participatory environmental activities, and environmentally friendly management of supporting facilities (Khasanah et al., 2025; Wardani, 2020). The implementation of these components is not only normative but also has a real impact in the field. The Adiwiyata program has been proven to increase the participation of students, teachers, and parents in environmental management while encouraging the formation of environmentally friendly habits at school (Komalasari et al., 2022; Nada et al., 2021; Nurwidodo et al., 2020; Nurwidodo et al., 2018; Rahmadiani et al., 2019; Wardani, 2020) and plays an important role in increasing students' ecological awareness (Khasanah et al., 2025; Prastiwi et al., 2019; Sigit et al., 2021). Furthermore, the integration of Adiwiyata values into daily educational practices not only strengthens the school ecosystem but also provides schools with opportunities to play a strategic role in building a sustainable environmental culture at the community level.

However, the main challenge in implementing environment literacy-based programs is bridging the gap between knowledge and actual behavior. Several studies have shown that although environmental knowledge can increase rapidly, behavioral change often requires a longer internalization process, social support, and continuous monitoring (Ardoin et al., 2020; Collado et al., 2022; Stevenson et al., 2013). This condition underscores the importance of interventions that not only focus on intensive training but also include periodic follow-ups, enabling students to reflect on their experiences, receive feedback, and refine their applied skills. This type of intervention model is believed to be more suitable for schools in coastal areas facing complex challenges due to climate change. Moreover, this layered approach also has the potential to foster collective awareness that extends beyond the individual level, institutionalizing it at the school and community levels (Monroe et al., 2019; Rickinson & McKenzie, 2021).

Although various studies have demonstrated the effectiveness of environmental education programs, a gap remains in their implementation in coastal schools, particularly in those that are just beginning to work towards achieving Adiwiyata status. Many initiatives still focus solely on cognitive aspects without providing sufficient space for the internalization of values and the formation of genuine behavior. This condition raises a fundamental question: how to design an intervention model that integrates cognitive, affective, and practical learning in a balanced manner, while also being relevant to the context of coastal schools vulnerable to climate change? To answer this question, this community service activity implemented and evaluated the Green Literacy Bootcamp at SMP Negeri 25 Semarang, a junior high school in the coastal area of Semarang City, which is pioneering its path towards becoming an *eco-school* under the Adiwiyata framework. The program was designed by combining intensive learning through communication training, environmental campaigns, and applied simulations with a series of follow-up activities that enabled the internalization of values and sustainable habits. The primary focus was on improving students' environmental literacy through a multidimensional evaluation that encompassed knowledge, attitudes, skills, and behavior, ensuring the intervention extended beyond the theoretical level to encourage actual change.

This study offers novelty by integrating environmental literacy development into a structured bootcamp model that combines intensive training, simulation-based learning, and longitudinal follow-up, tailored explicitly for coastal schools. Unlike previous studies that often emphasize either cognitive improvement or short-term interventions, this model positions environmental literacy as a multidimensional construct encompassing knowledge, affect, skills, and behavior. In doing so, it explicitly addresses the research problem of designing and evaluating a contextually relevant intervention model that bridges the gap between environmental knowledge and sustainable behavior among students in climate-vulnerable coastal schools. Scientifically, this study contributes to the field by validating the Environmental Literacy Instrument in the context of Indonesian coastal schools and applying PLS-SEM to examine the relative contribution of each dimension, thereby enriching the theoretical understanding of how environmental hope and cognitive skills interact as predictors of sustainable behavior. Accordingly, the objectives of this study are threefold: (1) to strengthen students' environmental literacy through the implementation of a Green Literacy Bootcamp, (2) to measure multidimensional changes in environmental literacy (including cognitive, affective, and behavioural aspects) before and after the intervention, and (3) to develop a replicable eco-school model that can inform environmental education policy in coastal contexts. Beyond its practical community service dimension, the study also provides scientific contributions by validating an integrative environmental literacy framework within the Adiwiyata eco-school context, enriching empirical understanding of literacy, behavior linkages, and offering a transferable model that bridges international evidence and local educational practice, thereby advancing the theoretical discourse on multidimensional environmental literacy within climate-vulnerable educational settings.

## METHOD

This community service activity was conducted through an empowerment approach that emphasized the strengthening of environmental literacy within the *Green Literacy Bootcamp* program. The program aimed to enhance the environmental capacity of students at Adiwiyata candidate schools in coastal areas, targeting 45 students from SMP Negeri 25 Semarang. The empowerment approach in environmental education has proven effective in fostering students' literacy, attitudes, and pro-environmental behavior, particularly within the Adiwiyata framework that promotes participatory learning and an environmentally conscious school culture (Anggraini & Karyanto, 2019). SMP Negeri 25 Semarang was purposively selected due to its geographical location in the coastal zone of Semarang City, which is highly vulnerable to climate-related hazards such as abrasion and tidal flooding. The

program was designed to develop environmentally aware and critical students who could act as agents of change. This choice also aligned with the school's vision as an environmentally oriented institution, ensuring that program outcomes could be sustained and integrated into the school's internal environmental initiatives.

The *Green Literacy Bootcamp* was implemented from July to September 2025 in three main phases. The first phase, a two-day intensive training, focused on improving communication and environmental awareness. Activities on the first day included public speaking exercises related to environmental issues, creative campaign design, and message delivery simulations, and the second day emphasized applied learning through eco-project practices, including creating mini biopores, Takakura composting, portable urban farming, and role-playing tidal flood mitigation. Each student group concluded the session by presenting a *School Green Action Plan* as a follow-up commitment to environmental action. The second phase consisted of a three-month follow-up period during which students implemented small-scale projects, including classroom waste management, home-based urban farming, and digital environmental campaigns. These projects were monitored every two to three weeks through guided reflection sessions facilitated by the community service team, enabling students to discuss progress and challenges. The third phase was a collective reflection forum used to share outcomes and formulate sustainability strategies. At this stage, the *Green Warrior* student team was established to maintain ongoing environmental literacy activities at SMP Negeri 25 Semarang.

Program evaluation employed a quantitative approach to ensure objective and measurable results. Two main instruments were used. The first was the Environmental Literacy Instrument (Husamah et al., 2022), which assesses four dimensions: Ecological Knowledge, Environmental Hope, Cognitive Skills, and Behavior. Responses were recorded on a four-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree), with the neutral option omitted to encourage more decisive responses. The instrument had previously demonstrated validity and reliability in environmental education contexts, making it appropriate for use in coastal schools. In addition to the paired sample t-test for comparing pre- and post-intervention scores, the study also employed Partial Least Squares-based Structural Equation Modeling (PLS-SEM). Although this study is categorized as a community service activity, the use of PLS-SEM is academically justified, as it enables the examination of structural relationships among the four dimensions of environmental literacy. This method offers a deeper insight into which components contribute most significantly to overall literacy formation, thereby linking empowerment-based interventions to a theoretical understanding. The use of PLS-SEM thus strengthens the academic rigor of community empowerment studies by connecting practical outcomes to empirical validation.

To complement the quantitative analysis, a participant satisfaction survey was conducted to measure perceptions of material quality, delivery methods, facilitator competence, and perceived benefits to students' knowledge and skills. Responses were analyzed descriptively to identify the program's strengths and areas for improvement. This combination of pre- and post-tests, structural model analysis, and satisfaction evaluation provided a comprehensive overview of the program's effectiveness and participant engagement. This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, emphasizing respect, informed consent, and voluntary participation. Prior to implementation, formal permission was obtained from SMP Negeri 25 Semarang, and all student participants, along with their parents or guardians, provided informed consent. No invasive or harmful procedures were involved in this activity.

## RESULTS AND DISCUSSION

The Green Literacy Bootcamp at SMP Negeri 25 Semarang was conducted in stages, beginning with a two-day intensive program followed by a series of follow-up activities. On the first day, the

focus was on strengthening communication skills and developing environmental campaigns. Through public speaking sessions, students were trained to convey environmental issues to their peers effectively. During the creative campaign workshop, students designed posters that demonstrated their understanding of key environmental issues, including climate change, waste reduction, and conservation. As illustrated in Figure 1, these posters captured the students' ability to translate ecological knowledge into persuasive visual messages, showing their creativity and awareness of local environmental challenges. The campaign simulation at the end of the session also revealed growing confidence among students in articulating environmental ideas and engaging their audience through impactful yet straightforward rhetoric. These findings are consistent with the studies by [Bowen et al. \(2025\)](#) and [Murgel et al. \(2025\)](#), which demonstrate that integrating communication training into environmental education enhances students' capacity to convey scientific and ecological messages effectively.



Figure 1. Environmental Campaign Poster

The second day emphasized applied, simulation-based learning. Interactive discussions with environmental activists provided students with a real-world understanding of the challenges along the Semarang coastline. Meanwhile, hands-on eco-projects, such as creating mini biopores, Takakura composting, and portable urban farming, enabled students to apply their learning in practical contexts. Disaster mitigation simulations, which utilize models and role-playing, strengthen teamwork, leadership, and problem-solving abilities. At the end of the session, each group developed a *School Green Action Plan* that contained implementable ideas, such as energy-saving programs, classroom waste management initiatives, and tree adoption activities. As shown in Figure 2, one of the student-designed plans demonstrates their capacity to convert conceptual knowledge into concrete, context-based environmental solutions that can be applied within their school ecosystem.



Figure 2. My School Green Action Plan

The action plan demonstrates the students' deep understanding of environmental issues. It is clear evidence that they can translate theoretical knowledge into concrete, implementable solutions. The plan not only reflects their creativity but also their readiness to become active agents of change in their school and community. This approach to learning, which emphasizes hands-on practice and technology-assisted learning, is highly effective and aligns with recent academic findings. Tsai et al. (2025) and Liu et al. (2020) demonstrate that interactive technology-assisted learning has a significant impact on enhancing environmental literacy and modifying attitudes, including fostering critical thinking and increasing motivation to take tangible action on environmental issues. Furthermore, a study by Könnel et al. (2025) demonstrates that even a single day of intensive outdoor learning can enhance ecological knowledge and environmental values. In contrast, Parayiwa and Shabalala (2025) demonstrate how direct involvement in projects such as school gardens and recycling can strengthen environmental awareness and commitment.

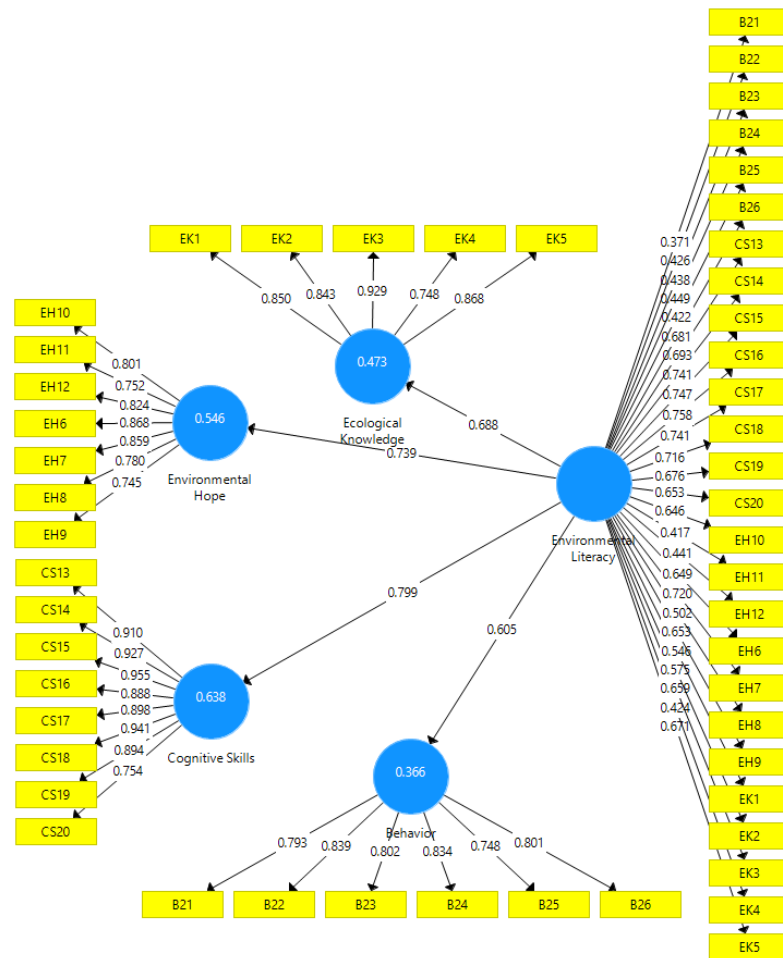
To ensure sustainability, activities do not stop at intensive training, but are followed up with a series of follow-ups every two to three weeks. At this stage, students undertake mini-projects relevant to their daily lives, reflect with community service team facilitators, and participate in structured environmental literacy monitoring. This mechanism serves as a process of internalization, ensuring that the knowledge gained does not remain at the cognitive level but instead develops into positive attitudes and more sustainable behavior. Environmental education based on direct interaction with nature has been proven effective in strengthening pro-environmental behavior (Zhao et al., 2024). In contrast, serial educational interventions have been shown to increase the consistency of students' understanding, attitudes, and behavior at school (Isenaj et al., 2025). This is also confirmed by studies showing that environmental education can transform green behavior while fostering hope (Chen et al., 2025; Husin et al., 2025), and reinforced by meta-analyses emphasizing the effectiveness of long-term interventions in strengthening pro-environmental knowledge, attitudes, and behavior at various levels of education (Hu et al., 2025). The effectiveness of this follow-up was then measured quantitatively using an environmental literacy instrument administered in the form of a pre-test and a post-test, allowing for the objective and measurable monitoring of the changes that occurred.

**Table 1.** Summary of Paired t-test Analysis

| Dimensions             | Paired Differences |                |                 | t (df)      | Sig   |
|------------------------|--------------------|----------------|-----------------|-------------|-------|
|                        | Mean               | Std. Deviation | Std. Error Mean |             |       |
| Environmental Literacy | 20.989             | 7.62535        | .80378          | 26.113 (89) | .000* |
| Ecological Knowledge   | 4.033              | 2.10644        | .22204          | 18.165 (89) | .000* |
| Environmental Hope     | 7.011              | 2.99248        | .31543          | 22.227 (89) | .000* |
| Cognitive Skills       | 5.444              | 3.69971        | .38998          | 13.961 (89) | .000* |
| Behaviour              | 4.500              | 2.70351        | .28498          | 15.791 (89) | .000* |

The quantitative evaluation using the Environmental Literacy Instrument, administered before and after the program, revealed a significant improvement across all measured dimensions. As shown in Table 1, students' environmental literacy increased markedly after participating in the Green Literacy Bootcamp ( $p < .01$ ). The most substantial gains were recorded in Environmental Hope (+7.01) and Cognitive Skills (+5.44), suggesting that participants not only expanded their conceptual understanding but also developed stronger optimism and problem-solving abilities in addressing environmental challenges. These results demonstrate that environmental literacy is most effectively cultivated through an integrative learning model that combines cognitive, affective, and behavioral components. The increase in Ecological Knowledge indicates deeper comprehension of key environmental concepts (Könnel et al., 2025), while the significant rise in Environmental Hope reflects

enhanced confidence in the possibility of positive environmental change, an affective factor closely linked to adolescents' motivation for pro-environmental action (Denault et al., 2024; Zhao et al., 2024). Similarly, the notable improvement in Cognitive Skills underscores students' growing capacity for critical thinking, analysis, and practical problem-solving (Tsai et al., 2025; Bowen et al., 2025). Although changes in Behavior were less pronounced, the positive trend suggests gradual internalization of sustainable habits, which typically require ongoing reinforcement and contextual support (Husin et al., 2025; Hu et al., 2025). Taken together, these findings affirm that the formation of environmental literacy emerges from the dynamic interaction between knowledge, attitudes, skills, and actions, highlighting the importance of holistic, experience-based learning in fostering sustainable environmental behavior among students.



**Figure 3.** Environmental Literacy Measurement Model

To further understand the structure of environmental literacy, a measurement model analysis using PLS-SEM was conducted to examine the relative contribution of each dimension to the overall construct. As depicted in Figure 3, the analysis confirmed that Cognitive Skills were the most dominant contributor ( $\lambda = 0.799$ ), followed by Environmental Hope ( $\lambda = 0.739$ ), Ecological Knowledge ( $\lambda = 0.688$ ), and Behavior ( $\lambda = 0.605$ ). These findings suggest that higher-order thinking abilities, such as critical analysis and problem-solving, form the primary foundation of students' environmental literacy, while affective dispositions, including optimism and confidence in environmental improvement, play a complementary role in sustaining engagement. The moderate loading of Ecological Knowledge suggests that conceptual understanding remains an essential but supporting factor, whereas the relatively lower Behavior dimension implies that translating awareness into

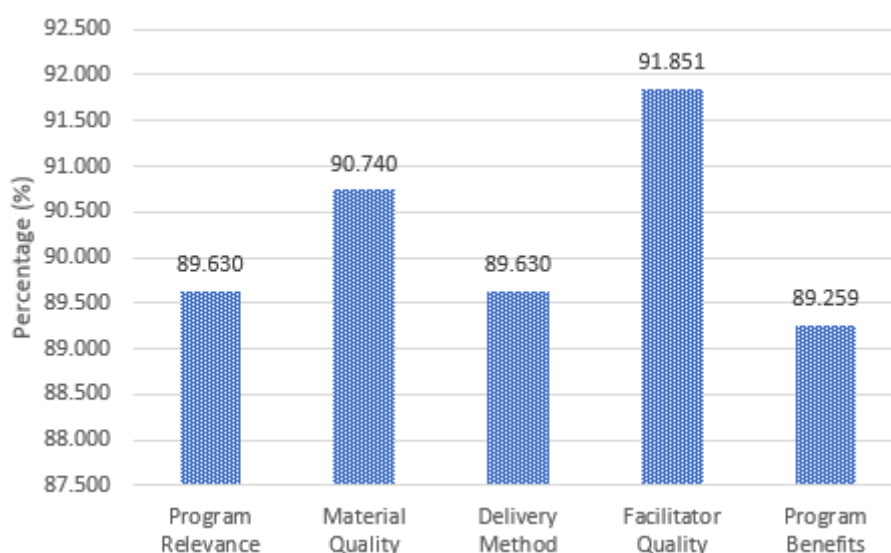
consistent actions requires time and reinforcement. Collectively, these results confirm that environmental literacy is a multidimensional construct shaped by the interaction of cognitive, affective, and behavioral domains (Napitupulu et al., 2025; Kerret et al., 2016), and that strengthening both critical thinking and environmental hope can substantially increase the likelihood of transforming knowledge into sustained pro-environmental action (Espinola & Roleda, 2021).

Conceptually, the four dimensions serve as first-order constructs that collectively form a second-order construct known as environmental literacy. This confirms that environmental literacy is a multidimensional construct that cannot be reduced to knowledge or behavior alone, but instead emerges from the interplay of cognitive, affective, and behavioral aspects (Napitupulu et al., 2025). The dominance of Cognitive Skills and Environmental Hope indicates that cognitive and affective aspects are essential foundations for consistent behavioral change to occur, because students who can think critically and maintain optimism are more likely to translate their understanding into sustainable actions (Kerret et al., 2016; Espinola & Roleda, 2021). Ecological Knowledge, while slightly less dominant, remains a crucial basis that provides the conceptual grounding for both attitudes and skills, whereas Behavior reflects the ultimate manifestation of these internal processes in daily practices. Thus, interventions should not only transfer information but also create opportunities for students to exercise problem-solving skills, engage in reflective practices, and cultivate hope for their environmental futures (Hajj-Hassan et al., 2024). This interpretation aligns with recent studies that emphasize the importance of intentionally integrating cognitive and affective domains into environmental education design for long-term, sustainable engagement (Benoit et al., 2025; Tan & Asna, 2023). Recognizing environmental literacy as a layered construct also provides educators and policymakers with a more precise roadmap for designing interventions, where strengthening higher-order thinking and fostering optimism become strategic priorities alongside knowledge transmission and behavioral monitoring.

Building on this theoretical mapping, the present findings not only confirm earlier studies but also extend current knowledge of environmental education in a novel way. Recent research from Indonesia highlights that sustainability and hope are central to teacher expectations, demonstrating that affective elements are just as important as cognitive ones (Husin et al., 2025). Likewise, project-based learning in coastal contexts has been shown to significantly improve not only students' scientific knowledge but also their willingness to engage in real environmental actions (Rusly et al., 2025). From another perspective, ethnoscience-based interventions analyzed through PLS-SEM reveal that integrating local wisdom and attitudes has a significant influence on the transition from knowledge to pro-environmental behavior (Fitriana et al., 2025). These findings collectively reinforce the view that environmental education should combine cognitive, affective, and contextual elements to achieve long-term behavioral change. Scientifically, this study advances environmental education by providing contextualized empirical validation of a multidimensional model in a coastal school setting, while practically offering a roadmap for implementing Adiwiyata, focusing on measurable skills, attitudes, and behaviors. This evidence provides a strong foundation for discussing the relevance of these findings in the context of Adiwiyata candidate schools, where policy integration and school culture play a decisive role in sustaining environmental literacy outcomes.

In the context of Adiwiyata candidate schools, this understanding is highly relevant because the Adiwiyata program emphasizes the integration of the curriculum, school culture, and school community participation in environmental conservation (Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia, 2022). Schools that implement Adiwiyata have also proven successful in integrating environmental values into inclusive activities that encourage the participation of the entire school community (Wibowo et al., 2024). The success of the Adiwiyata program even depends heavily on strategies for strengthening values, repeated habituation, and school community

involvement (Anggraini et al., 2024). Furthermore, the implementation of Adiwiyata can tangibly improve students' environmental problem-solving skills (Istiningsih et al., 2024). Therefore, the results of this measurement model provide a practical foundation for SMP Negeri 25 Semarang to direct strategies for strengthening environmental literacy, for example, through project-based learning to strengthen cognitive skills, creative campaigns to foster environmental hope, and a behavior monitoring system to form consistent and sustainable real actions (Taufik et al., 2015).



**Figure 4.** Green Literacy Bootcamp Satisfaction Evaluation (%)

In addition to assessing literacy outcomes, the program's effectiveness was also evaluated through a participant satisfaction survey. As illustrated in Figure 4, students reported very high satisfaction levels across four indicators: facilitator quality (91.85%), material relevance (90.74%), delivery methods (89.63%), and perceived benefits (89.26%). The highest score for facilitator quality indicates that participants highly valued the facilitators' competence in delivering materials, motivating engagement, and guiding practical activities. Similarly, the strong ratings for material relevance and delivery methods reflect students' perception that the content was contextually appropriate and presented engagingly. The slightly lower score for perceived benefits is understandable, as the long-term effects of the program, such as sustained behavioral consistency and institutional culture change, require more time to be fully realized.

These findings align with Collado et al. (2022) and Pan and Hsu (2022), who reported that the positive outcomes of sustainability education interventions tend to emerge gradually over extended periods, particularly when supported by continuous experiential learning. The results also complement the quantitative evidence presented earlier, demonstrating that the Green Literacy Bootcamp not only enhanced students' cognitive and affective engagement with environmental issues but also laid a foundation for sustainable behavioral development and eco-school culture. The combination of intensive learning, contextual application, and continuous mentoring thus represents an effective model for cultivating environmental literacy in coastal schools. Scientifically, the use of PLS-SEM strengthens the empirical foundation of this community service project by linking practical empowerment outcomes with theoretical understanding of environmental literacy formation, providing valuable insights for the development of Adiwiyata-based environmental education in other climate-vulnerable contexts.

## CONCLUSION

The Green Literacy Bootcamp proved effective in strengthening students' environmental literacy, as reflected by consistent improvements across ecological knowledge, environmental hope, cognitive skills, and behavior. These gains were further supported by positive participant feedback regarding facilitator quality, material relevance, delivery methods, and program impact. Beyond achieving the community service goal of empowering prospective Adiwiyata schools in coastal areas, the findings hold broader scientific significance by contributing a replicable, simulation-based intervention model that underscores the cognitive and affective foundations of sustainable behavior. However, this study also has several limitations. The evaluation primarily relied on self-reported data, which may not fully capture actual behavioral change, and the observation period was relatively short, covering only three months of follow-up. Future research should therefore employ longitudinal or mixed-method approaches to examine behavioral consistency over time, incorporate control groups for comparative analysis, and explore the qualitative dimensions of students' environmental engagement. Further replication of this model in diverse educational settings (urban, rural, and non-coastal) would also strengthen its generalizability and inform the development of adaptable frameworks for eco-school implementation in other vulnerable contexts.

## ACKNOWLEDGEMENTS

The author would like to express gratitude to the Directorate of Research and Community Service, Ministry of Higher Education, Science, and Technology (DPPM Kemendikristek), for funding support for this community service activity based on Master Contract Number: 085/C3/DT.05.00/PM/2025. Gratitude is also extended to the Research and Community Service Institute of Universitas Negeri Semarang for facilitating the implementation of this program through Subcontract Number: 162.2.6/UN37/PPK.11/2025. The support from the school, particularly SMP Negeri 25 Semarang, along with all the teachers and students who participated as Green Warriors, was instrumental in the success of this program.

## REFERENCES

- Anggraini, R., Utaya, S., & Ruja, I. N. (2024). Adiwiyata as an Effective Environmental Education Program: How to Create and Maintain It?. *Jurnal Komunikasi Pendidikan*, 8(2), 170-183.
- Anggraini, W., & Karyanto, P. (2019, Juni). School and Teachers' Role to Empowerment of Environmental Literacy in Prominent Middle School Based on Adiwiyata Program. Dalam *Journal of Physics: Conference Series* (Vol. 1233, No. 1, hlm. 012084). IOP Publishing.
- Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental Education Outcomes for Conservation: A Systematic Review. *Biological Conservation*, 241, 108224.
- Benoit, L., R. Lowe, S., Thomas, I., Amsalem, D., & Martin, A. (2025). Climate Change Hopefulness, Anxiety, and Behavioral Intentions Among Adolescents: Randomized Controlled Trial of a Brief "Selfie" Video Intervention. *Child and Adolescent Psychiatry and Mental Health*, 19(1), 13-25.
- Bowen, C. D., Coscia, K. A., Aadnes, M. G., Summersill, A. R., & Barnes, M. E. (2025). Undergraduate Biology Students' Climate Change Communication Experiences Indicate a Need for Discipline-Based Education Research on Science Communication Education About Culturally Controversial Science Topics. *CBE Life Sciences Education*, 24(2), 1-19.
- Chen, C, Shahbaz, P., & Haq, S. (2025). Transforming Students' Green Behavior Through Environmental Education: The Impact of Institutional Practices and Policies. *Frontiers in Psychology*, 15, 1499781.
- Chuang, T. Y., Tsai, S. K., & Lu, Y. H. (2025). Technology-Enhanced Digital Game-Based Learning for Environmental Literacy: Catalyzing Attitude Change in Learners. *Frontiers in Education*, 10, 1629670.

- Collado, S., Moreno, J. D., & Martín-Albo, J. (2022). Innovation for Environmental Sustainability: Longitudinal Effects of an Education for Sustainable Development Intervention on University Students' Pro-Environmentalism. *International Journal of Sustainability in Higher Education*, 23(6), 1277–1293.
- Denault, A. S., Bouchard, M., Proulx, J., Poulin, F., Dupéré, V., Archambault, I., & Lavoie, M. D. (2024). Predictors of Pro-Environmental Behaviors in Adolescence: A Scoping Review. *Sustainability*, 16(13), 5383–5419.
- Espinola, E., & Roleda, L. (2021). Climate Change Perception, Action, and Hope Among High School Students: Insights for Science Education. *Jurnal Pendidikan IPA Indonesia*, 10(3), 388–399.
- Fitriana, N., Dasna, I. W., Munzil, M., Utomo, Y., Rahayu, S., Habiddin, H., Purwanto, K. K., & Ikawati, A. (2025). Empowering Sustainable Action: PLS-SEM Analysis of Ethnoscience-Based Learning for Pro-Environmental Behavioral Change in East Java University Students. *Multidisciplinary Science Journal*, 8(2), 34–48.
- Hajj-Hassan, M., Chaker, R., & Cederqvist, A. M. (2024). Environmental Education: A Systematic Review on the Use of Digital Tools for Fostering Sustainability Awareness. *Sustainability*, 16(9), 3733–3758.
- Hu, B., Wang, C., Xia, Z., Lu, C., & Ju, X. (2025). Environmental Education in Low-Income and Middle-Income Countries: A Systematic Review and Meta-Analysis. *Journal of Environmental Psychology*, 104, 102613.
- Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). The Development and Validation of Environmental Literacy Instrument Based on Spirituality for Prospective Science Teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(12), 1–15.
- Husin, A., Helmi, H., Nengsih, Y. K., & Rendana, M. (2025). Environmental Education in Schools: Sustainability and Hope. *Discover Sustainability*, 6(1), 41–52.
- Isenaj, Z. S., Moshammer, H., Berisha, M., & Weitensfelder, L. (2025). Effect of an Educational Intervention on Pupil's Knowledge, Attitudes, Perceptions, and Behavior on Air Pollution in Public Schools in Pristina. *European Journal of Investigation in Health, Psychology and Education*, 15(5), 69–88.
- Istiningsih, G., Sukmarani, D., Sugiarti, I. Y., & Putri, N. U. (2024). The Effectiveness of the Adiwiyata Program in Enhancing Environmental Problem-Solving Skills. *5th Borobudur International Symposium on Humanities and Social Science (BIS-HSS 2023)*. IOP Conference Series: Earth and Environmental Science, 1145(1), 012089.
- Iwaniec, J., & Curdt-Christiansen, X. L. (2020). Parents as Agents: Engaging Children in Environmental Literacy in China. *Sustainability*, 12(16), 6605–6617.
- Katmie, K. (2025). Pengembangan Modul Ajar Mitigasi dan Adaptasi Perubahan Iklim Berbasis EzGCM pada Mata Pelajaran Muatan Lokal untuk Siswa SMA/MA. *Jurnal Ilmiah Kanderang Tingang*, 16(1), 127–132.
- Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia. (2022). *Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor 23 Tahun 2022 tentang Penghargaan Adiwiyata*. Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia.
- Kerret, D., Orkibi, H., & Ronen, T. (2016). Testing a Model Linking Environmental Hope and Self-Control with Students' Positive Emotions and Environmental Behavior. *The Journal of Environmental Education*, 47(4), 307–317.
- Khasanah, D. M., Zulaikha, S., & Santosa, H. (2025). Increasing Environmental Awareness Through the Implementation of the Adiwiyata Mandiri Program at SMAN 1 Sukakarya. *Sosioedukasi: Jurnal Ilmiah Ilmu Pendidikan dan Sosial*, 14(3), 1290–1296.
- Komalasari, A., Dewantara, J. A., Prasetyo, W. H., & Rahmanie, E. F. (2022). Futures for Pro-Environment and Social Responsibility Activities in Indonesian Schools: An Adiwiyata Case Study. *Issues in Educational Research*, 32(2), 746–764.

- Könnel, E. J., Geuer, L., Schlindwein, A., Perret, S., & Ulber, R. (2025). The Effects of an Outdoor Learning Program, 'GewässerCampus', in the Context of Environmental Education. *Education Sciences*, 15(5), 550–574.
- Liu, P., Teng, M., & Han, C. (2020). How Does Environmental Knowledge Translate into Pro-Environmental Behaviors?: The Mediating Role of Environmental Attitudes and Behavioral Intentions. *Science of the Total Environment*, 728, 138126.
- Mochizuki, Y., & Bryan, A. (2015). Climate Change Education in the Context of Education for Sustainable Development: Rationale and Principles. *Journal of Education for Sustainable Development*, 9(1), 4–26.
- Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying Effective Climate Change Education Strategies: A Systematic Review of the Research. *Environmental Education Research*, 25(6), 791–812.
- Murgel, M., Campos, A. P. C., Viana, M. B., & Lima, L. S. (2025). Science Communication Project: Articulating Teaching in Environmental Chemistry. *Journal of Chemical Education*, 102(3).
- Nada, H. N., Fajarningsih, R. U., & Astirin, O. P. (2021). Adiwiyata (Green School) Program Optimization Strategy in Malang Regency to Realize Environmentally Friendly School Citizens. *IJORER: International Journal of Recent Educational Research*, 2(2), 121–137.
- Napitupulu, N. D., Novianti, I., Iduard, I., Rutmiyanti, R., Ibrahim, I., & Embatau, K. S. (2025). Environmental Literacy in Middle School: Ecological Knowledge, Cognitive Skills, Environmental Affect, and Pro-Environmental Behavior. *Jurnal Eduscience*, 12(2), 281–296.
- Nurwidodo, N., Amin, M., Ibrohim, I., & Sueb, S. (2020). The Role of Eco-School Program (Adiwiyata) Towards Environmental Literacy of High School Students. *European Journal of Educational Research*, 9(3), 1089–1103.
- Nurwidodo, N., Hendayana, S., & Hindun, I. (2018). Building Pro-Environmental Behavior Among School Community of Adiwiyata Green School. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 4(1).
- Pan, C. T., & Hsu, S. J. (2022). Longitudinal Analysis of the Environmental Literacy of Undergraduate Students in Eastern Taiwan. *Environmental Education Research*, 28(10), 1452–1471.
- Parayiwa, S. P., & Shabalala, N. P. (2025). Nurturing Environmental Awareness: How High School Students in Johannesburg are Shaping a Greener Future. *International Journal of Development Education and Global Learning*, 17(1), 22–39.
- Pe'er, S., Goldman, D., & Yavetz, B. (2007). Environmental Literacy in Teacher Training: Attitudes, Knowledge, and Environmental Behavior of Beginning Students. *The Journal of Environmental Education*, 39(1), 45–59.
- Podungge, A. W., & Solihin, D. I. Y. (2025). Education-Based Disaster Mitigation: A Case Study of Coastal Communities Vulnerable to Climate Change. *JETL (Journal of Education, Teaching and Learning)*, 10(1), 239–251.
- Prasetyo, W. H., Ishak, N. A., Basit, A., Dewantara, J. A., Hidayat, O. T., Casmana, A. R., & Muhibbin, A. (2020). Caring for the Environment in an Inclusive School: The Adiwiyata Green School Program in Indonesia. *Issues in Educational Research*, 30(3), 1040–1057.
- Prastiwi, L., Sigit, D. V., & Ristanto, R. H. (2019). Ecological Literacy, Environmental Awareness, Academic Ability and Environmental Problem-Solving Skill at Adiwiyata School. *Indonesian Journal of Science and Education*, 3(2), 82–92.
- Rahmadiani, R., Utaya, S., & Bachri, S. (2019). Ecological Literacy Siswa SMA Adiwiyata dan Non Adiwiyata. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, 4(4), 499–503.
- Rickinson, M., & McKenzie, M. (2021). The Research-Policy Relationship in Environmental and Sustainability Education. *Environmental Education Research*, 27(4), 465–479.
- Rusly, N., Toge, S., & Tualeka, E. (2025). The Effect of Coastal Environment-Based Project-Based Learning Model on the Science Literacy Skills of Elementary School Students at SD Negeri 127 in South Halmahera. *International Journal of Education, Information Technology, and Others*, 8(2), 27–32.

- Sigit, D. V., Prastiwi, L., Ristanto, R. H., & Rifan, M. (2021, Februari). Adiwiyata School in Indonesia: A Correlation Between Eco-Literacy, Environmental Awareness, and Academic Ability With Environmental Problem-Solving Skill. Dalam *Journal of Physics: Conference Series* (Vol. 1796, No. 1, hlm. 012068). IOP Publishing.
- Stevenson, K. T., Peterson, M. N., Bondell, H. D., Mertig, A. G., & Moore, S. E. (2013). Environmental, Institutional, and Demographic Predictors of Environmental Literacy Among Middle School Children. *PloS One*, 8(3), e59519.
- Tan, C. K., & Asna, H. N. (2023). Serious Games for Environmental Education. *Integrative Conservation*, 2(1), 19-42.
- Taufik, D., Bolderdijk, J. W., & Steg, L. (2015). Acting Green Elicits a Literal Warm Glow. *Nature Climate Change*, 5(1), 37-40.
- Tsai, S. K., Chuang, T. Y., & Lin, Z. J. (2025). Enhancing Environmental Literacy Through Digital Game-Based Learning: A Technology-Integrated Attitude Change Approach. *Sustainability*, 17(16), 7416-7430.
- Wardani, D. N. K. (2020). Analisis Implementasi Program Adiwiyata dalam Membangun Karakter Peduli Lingkungan. *Southeast Asian Journal of Islamic Education Management*, 1(1), 60-73.
- Yuliani, S., Disman, D., Maryani, E., Nurbayani, S., & Lukman, E. P. (2024). Revealing the Social Learning Needs of Coastal Schools Based on SWOT Analysis. *Eduexos Jurnal Pendidikan Sosial & Ekonomi*, 13(1), 174-188.
- Zhao, Y., Liu, X., & Han, X. (2024). Enhancing Pro-Environmental Behavior Through Nature-Contact Environmental Education: An Empirical Analysis Based on Randomized Controlled Experiment Design. *Frontiers in Environmental Science*, 12, 1491780.