

# Green Education in Addressing Climate Change: An Empirical Study of Ecological Literacy through the Adiwiyata Program

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**Abstract.** Environmental education plays an important role in students' ecological literacy on climate change issues and is a challenge in Adiwiyata Schools. This research aims: (1) to examine the implementation of the Adiwiyata school program in addressing climate change; and (2) to analyze students' ecological literacy in Adiwiyata schools. There is a difference with previous research which focused on the effectiveness of the green school program, this research focuses on the study of ecological literacy with a case study of the Adiwiyata school. The study employs a mixed-methods approach with an exploratory sequential design. The research subjects included four senior high schools in Pati Regency. Data were collected through questionnaires and interviews and then analyzed using Ridder's interactive analysis model. The findings reveal that the integration of environment-based actualization learning, including project-based learning in waste management activities, tree planting activities known as the "Green Planet Project," school environmental cleaning activities known as the "Clean Campus Project", and river cleaning programs in surrounding areas known as the "Clean River Project", significantly enhanced students' caring aspects, practical competencies, and ecological knowledge. The Adiwiyata School Program proved effective in developing and enhancing ecological literacy to address climate change through collaborative and sustainable curricula and activities.

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## 1 Introduction

Global developments in the 21st century are characterized by the urgent need to address environmental issues. Accelerated technological development and unprecedented population expansion have driven Earth in the 21st century to reach a critical environmental crisis point, generating multiple interconnected ecological challenges. Increasing environmental issues such as climate change, sea pollution, and environmental degradation have become global challenges. One contributing factor to these issues is the lack of awareness and concern for the environment among individuals, including students. Many students still have a limited understanding of environmental issues, reflected in their minimal participation in environmental conservation activities and lack of awareness regarding the impact of human activities on ecosystems. There are findings in previous research that student ecoliteracy in Pati Regency is still low [1]. Based on the New Ecological Paradigm (NEP), the environmental care attitudes of students in Adiwiyata schools in Pati were only in the moderate category with an index of 69.67%. These data indicate that the younger generation has not yet understood their role in addressing environmental problems.

The younger generation, including students, has a strategic role in addressing environmental problems. Their strategic role lies in their superior adaptive attitudes, technological literacy, and critical thinking in seeking innovative solutions to complex environmental problems. The younger generation is not only capable of advocating sustainable practices but also initiating various leadership programs that support environmental conservation, such as environmental cleanup campaigns, reforestation projects, sustainable tourism development, organic farming promotion, waste reduction strategies, and water conservation programs. Therefore, enhancing ecological understanding from school age becomes crucial, as in-depth knowledge of ecology can expand environmentally friendly behavior among students. The low ecological literacy condition in Pati demands the implementation of more innovative and effective educational strategies to improve students' ecological literacy and environmental awareness. Efforts to improve ecological literacy Ecological literacy is in line with the concept of Education for Sustainable Development (ESD) initiated by UNESCO in the early 1990s and proclaimed by the United Nations through the Decade of Education for Sustainable Development, which focuses on caring attitudes, active participation of the younger generation, and critical thinking skills in facing climate change.

The concept of Education for Sustainable Development (ESD) has been implemented in Germany, integrated with Planetary Health, which aims to shape students who are aware of the impact of climate change on human health. Students are trained to think critically about the relationship between the environment, society, and health. In addition, students are also trained to present their simple research findings on climate change to the community [2]. The concept of Education for Sustainable Development (ESD) is also implemented in the US, UK, and Nordic countries in the form of Outdoor Education for Sustainable Development (OESD). Its implementation focuses on changing students' mindsets by combining geography, biology, chemistry, and social science learning. Learning is conducted based on nature, place, community, and technology to train students' systematic competencies.

A significant effort that has been implemented in schools to increase environmental awareness and students' ecological literacy is through the Adiwiyata School program. This program aims to encourage schools to implement environmentally friendly principles and develop students' character to care about environmental sustainability. To achieve the program's objectives, four main components are implemented to realize Adiwiyata schools: (1) developing environmentally friendly principles, (2) implementing environment-based

curricula, (3) conducting participatory environmental activities, and (4) managing eco-friendly support facilities. Environmental care attitude can be assessed based on three criteria: (1) recognizing that current environmental issues are crucial problems that must be immediately addressed with effective solutions; (2) consistently supporting every policy or regulation related to environmental protection; (3) actively participating in efforts to solve environmental problems. Based on this, environmental actualization in the Adiwiyata School program becomes an important aspect to examine. Learning about ecology should not be limited to theory but must also be manifested in concrete actions or active participation from students to address environmental problems.

In the ecopedagogy approach, it is emphasized that environmental education is not only cognitive but also transformative because it can motivate students to change their perspectives. The ecopedagogy approach emphasizes that environmental education is not only cognitive, but also transformative, which can encourage students to change their perspectives and behaviors towards the environment. Therefore, the Adiwiyata program in Indonesia can be a local practice that supports the global discourse on climate education and sustainability. Students' environmental care character can be improved through habituation and also an active school culture in addressing environmental problems. This is in line with the Theory of Planned Behavior which states that a person's behavior depends on their awareness. Factors that influence this are attitudes towards behavior, subjective norms, and perceived behavioral control. The application of this theory can be applied with the Adiwiyata program in the school environment to instill habits and awareness in high school students to realize Education for Sustainable Development (ESD).

Environmental actualization can be implemented through Project-Based Learning (PBL) models, which have been proven to enhance ecological literacy knowledge and students' learning outcomes in environmental conservation materials through project creation involving waste and used goods utilization into more valuable items. Environment-based actualization approaches enable students to directly apply the ecological knowledge they acquire through various real activities that impact the surrounding environment, ultimately enhancing ecological literacy. This is in line with previous research findings that school participation in the eco-school program in Flanders can increase students' environmental knowledge [3]. The implementation of green schools can not only influence behavior but can also have an impact on climate change because it uses an environmental education curriculum, such as that implemented in Afghan schools that includes climate change issues. This curriculum provides basic knowledge about climate, instills an attitude of environmental concern, and encourages students to adapt and mitigate the negative impacts of climate change.

Ecological literacy is defined as the ability to understand basic ecological concepts underlying environmental dynamics and problems. Through ecological literacy, individuals can make appropriate decisions and implement innovative solutions in facing complex environmental challenges. Ecological literacy skills should ideally be introduced from elementary school age so that children's cognitive, affective, and psychomotor development can develop optimally. However, based on the results of observations, the level of ecological literacy among students in Pati is still relatively low. This condition emphasizes the need for more effective educational strategies to improve ecological literacy. Environmental actualization strategies become relevant for enhancing deeper ecological literacy because these approaches not only present environmental materials theoretically but also foster students' active participation in waste management and environmental problem-solving. Therefore, this research investigates the effectiveness of the Adiwiyata school program in addressing climate change, focusing on SMA Negeri 1, SMA Negeri 2, SMA Negeri 3, and SMA Negeri 1 Kayen in Pati Regency, to examine how the program enhances ecological

literacy and promotes active student participation in environmental sustainability efforts related to climate change mitigation.

## **2 Methods**

### **2.1 Research Design**

This research aims to investigate the implementation conditions of the Adiwiyata School program in Pati Regency and analyze students' ecological literacy abilities in Adiwiyata Schools. This study employs a mixed-methods approach combining qualitative and quantitative approaches. Mixed methods are popular because they can provide more complete explanations with data presentation accompanied by descriptions of research findings. Data validity and reliability will be ensured through the integration of qualitative and quantitative methods. The research design implements an exploratory sequential design. The exploratory sequential design phases are divided into the first phase with a qualitative approach for data interpretation, while the second phase applies a quantitative approach for data confirmation and verification.

### **2.2 Research Subjects**

Ecological literacy data were collected from various senior high schools in Pati Regency. The selection of research locations was determined based on the frequency of environmental issues in these areas and the study's focus on Adiwiyata Schools, specifically SMAN 1 Pati, SMAN 2 Pati, SMAN 3 Pati, and SMAN 1 Kayen. In line with the findings of previous research which prove that Pati Regency often experiences environmental problems such as flooding, drought and garbage piles. Within these selected schools, purposive sampling was employed to determine research subjects based on students' average learning outcomes, with criteria focusing on both the highest and lowest performing students to ensure comprehensive representation

### **2.3 Research Instruments**

Ecological literacy was assessed using instruments employing four-point Likert scales ranging from very low (score 1), low (score 2), high (score 3), and very high (score 4). The research instrument was developed collaboratively by a research team consisting of two Professors with more than 30 years of experience, one Senior Lecturer with more than 10 years of experience, and two Geography Education Doctoral Lecturers with research fields in environmental education and learning. Validation was carried out with a limited trial of 40 students, including 10 students of SMA Negeri 1 Pati, 10 students of SMA Negeri 2 Pati, 10 students of SMA Negeri 3 Pati and 10 students of SMA Negeri 1 Kayen. Validity and reliability tests used SPSS version 25 with consideration of the level of accuracy and effectiveness in proving validity and reliability data. The results of the analysis proved that the ecological literacy data is included in the valid category with a sig value  $> r$  table = 0.312. Furthermore, the reliability of the data in the ecological literacy questionnaire is included in the reliable category with a cronbach's alpha value  $> r$  table showing a cronbach's alpha reliability coefficient  $> 0.60$ .

## **2.4 Data Collection and Analysis Techniques**

Comprehensive data were collected in 7 days through questionnaires distributed using Google Forms to Adiwiyata School students. Data analysis employed Ridder's interactive analysis model, encompassing four sequential stages: data collection, data reduction, data presentation, and conclusion drawing. The study utilized both quantitative and qualitative data sources. Quantitative data were gathered through a 35-item questionnaire designed to measure ecological literacy levels. Qualitative data were obtained through in-depth interviews to contextualize and explain quantitative findings, thereby providing a comprehensive understanding of students' ecological literacy in Adiwiyata Schools. The results of quantitative and qualitative data were then analyzed to obtain conclusions regarding the study of ecological literacy on the Adiwiyata school program.

## **3 Results and Discussion**

### **3.1 Implementation of the Adiwiyata School Program**

Ecological literacy research provides valuable insights when examined within the context of Adiwiyata Schools. The Adiwiyata program operates on three foundational principles: educative, collaborative, and sustainable approaches. Education serves as a critical driver for enhancing ecological literacy. Previous research demonstrates that learning experiences create lasting impacts on individual knowledge acquisition. The integration of environmental education has emerged as an effective strategy for strengthening ecological literacy. This aligns with previous findings that identify environmental education as the primary mechanism for improving ecological understanding. Furthermore, environmental education encompasses key areas including natural ecosystem functions, human environmental impacts, and sustainable resource management practices.

The Adiwiyata school program aims to foster environmental protection commitment while achieving sustainable development goals. This study's findings confirm that the program's core indicators center on integrating environment-based curricula into educational frameworks. Such curriculum implementation represents a systematic approach to environmental management within school settings. Adiwiyata Schools in Pati Regency operationalize these environment-based curricula through three key components: developing comprehensive lesson plans, creating environment-focused learning materials, and implementing hands-on environmental activities.

This approach reflects a global trend in environmental education integration. Similar initiatives have been successfully implemented across various countries: Portugal has incorporated environmental curricula to enhance ecological literacy and engage students in conservation activities [4]; Romania utilizes environmental education as a strategic tool for conservation, environmental protection, and knowledge enhancement [5]; while Japan emphasizes formal environmental education to support sustainable development objectives [6]. In Pati Regency, the planning and implementation of environment-based curricula are carefully aligned with existing subject matter content across all Adiwiyata Schools.

Environment-based curricula are characterized by the development of learning activities through environmental actualization approaches. This comprehensive implementation requires active participation from all school community stakeholders, including teachers, academic staff, school maintenance personnel, and most importantly, students in environmental actualization learning processes. The program's effectiveness is further enhanced through the involvement of external stakeholders, particularly parents and surrounding communities, who provide crucial support for environmental actualization learning implementation [7]. Furthermore, the curriculum design also emphasizes the

integration of theoretical learning materials with practical environmental actualization activities. Environmental actualization learning encompasses three primary focus areas: school-based environmental management practices, the development of environmental value-oriented policies, and the generation of innovative environmental conservation strategies. The implementation of these environmental actualization learning activities is illustrated in Figure 1.



**Fig. 1.** Environmental Actualization Learning

Figure 1 demonstrates how environmental actualization learning is embedded within the daily educational activities of students and teachers across Adiwiyata Schools. The implementation varies across four different school programs:

- a) SMA Negeri 1 Pati implements environmental education through project-based learning focused on plastic waste recycling. Research indicates that project-based learning effectively enhances students' critical environmental awareness [8]. Through this approach, students gain practical experience in transforming waste materials into valuable and economically viable products. Students also develop an understanding of plastic waste hazards, particularly from repeated use. This environmental knowledge empowers students to prevent environmental degradation and respond proactively to climate change challenges [9].
- b) SMA Negeri 2 Pati operates the "Green Planet Project" through a tree planting initiative. This program engages not only students as primary participants but also includes broader school community involvement from teachers and staff. This enhances students' environmental literacy through learning experiences about plant cultivation. This practical learning approach aligns with research demonstrating that environmental experiences improve environmental literacy. This also aligns with Edgar Dale's theory that learning experiences are effective when integrated into learning [10]. Tree planting serves as a crucial intervention for mitigating global warming and climate change impacts.

- c) SMA Negeri 3 Pati features the distinctive "Clean Campus Project". This daily morning initiative requires student participation in community service activities to maintain school environmental cleanliness. Maintaining waste-free environments, both organic and inorganic, contributes significantly to temperature regulation and climate stability within the school environment [11].
- d) SMA Negeri 1 Kayen conducts the "Clean River Project", targeting river systems surrounding the school through monthly cleaning activities. This initiative specifically addresses flood prevention, a recurring environmental challenge at this location. The collaborative efforts of teachers, students, and staff in implementing river cleaning programs effectively reduce waste accumulation and mitigate environmental problems. Research supports that direct environmental interaction through action-based approaches enhances environmental literacy while reducing aquatic ecosystem damage, contributing to SDG 14: Life Below Water [12].

### 3.2 Students' Ecological Literacy in Adiwiyata Schools

Ecological literacy, also referred to as ecological intelligence, encompasses an individual's capacity to comprehend the complex interconnections within Earth's living systems. This concept extends beyond theoretical understanding to include an individual's conscious engagement with environmental issues, enabling them to implement concrete conservation actions. The primary goal of ecological literacy within Adiwiyata Schools is to develop sustainable thinking approaches across all subjects and student age levels. Furthermore, ecological literacy is evaluated through three core dimensions: caring aspects, practical competency aspects, and knowledge aspects. The comprehensive assessment results of students' ecological literacy across Senior High Schools in Pati Regency are presented in Table 1.

**Table 1.** Students' Ecological Literacy in Adiwiyata Schools

| Indicator               | Statistics     | Adiwiyata Schools |                |                |                 |
|-------------------------|----------------|-------------------|----------------|----------------|-----------------|
|                         |                | SMAN 1<br>Pati    | SMAN 2<br>Pati | SMAN 3<br>Pati | SMAN 1<br>Kayen |
| Caring                  | Mean           | 33,83             | 30,58          | 32,93          | 38,70           |
|                         | Percentage (%) | 70,47%            | 63,70%         | 68,59%         | 66,93%          |
|                         | Category       | High              | High           | High           | High            |
| Practical<br>Competency | Mean           | 33,28             | 34,18          | 32,00          | 31,83           |
|                         | Percentage (%) | 69,32%            | 71,20%         | 66,67%         | 66,30%          |
|                         | Category       | High              | High           | High           | High            |
| Knowledge               | Mean           | 31,43             | 31,70          | 32,73          | 41,08           |
|                         | Percentage (%) | 65,47%            | 66,09%         | 68,18%         | 63,75%          |
|                         | Category       | High              | High           | High           | High            |

The caring indicator reveals that SMA Negeri 1 Pati achieved the highest score of 70.47%, placing it in the high category for students' ecological literacy. This demonstrates strong environmental concern among students, evidenced by their consistent practice of separating organic and inorganic waste. These findings support previous research indicating that environmental concern develops through active participation in environmental management and control activities. Furthermore, student environmental concern is enhanced when students actively engage with their environment through conservation practices. Research in China shows that high school students have a positive attitude towards environmental issues, but its application in real action is still limited because learning

facilities and strategies are less than optimal [13]. Meanwhile, in Germany itself, it shows higher achievements where high school students not only have concern (caring) but are also involved in climate-friendly schools, for example energy and emission management, this is also supported by the integration of the Education for Sustainable Development (ESD) curriculum [2]. Therefore, literacy in Indonesia is relatively high, but there is a need for sustainable practices and structural support.

The practical competency indicator demonstrates that SMA Negeri 2 Pati achieved the highest score of 71.20%. This high performance is evidenced through students' active participation in environmental activities, including waste collection and reforestation projects within the school environments. These results support previous research showing that environmental practices effectively enhance ecological literacy. The approach also reflects Kolb's theory, which emphasizes that students best internalize knowledge through direct, practical engagement with their environment. Similar findings from research in China further validate this approach, where students demonstrated improved environmental understanding through practical waste processing activities. Programs in China, through the Green School Program policy, involve students in recycling, energy management, and waste management, raising awareness of sustainable living [14]. This context emphasizes similar applications that focus on waste management as part of the school curriculum. Meanwhile, in Germany, ecological literacy education is integrated into the program through outdoor education activities such as reforestation, energy conservation, and climate management in the school environment [2]. This aspect shows that student involvement increases practical competence in ecological skills. In Indonesia, through the context of environmental education, the focus is still on school-based practices, compared to Germany, which receives stronger structural support.

The knowledge indicator reveals that SMA Negeri 3 achieved the highest score of 68.18%. This demonstrates that students possess a substantial understanding of environmental issues and challenges. The integration of environmental education through the Adiwiyata program serves as the foundation for enhancing knowledge components within ecological literacy. Environmental education effectively builds both competencies and knowledge, equipping students with the ability to identify environmental problems and develop appropriate solutions. This is in line with previous findings that students' attitudes toward the environment depend on their ecological knowledge and literacy acquired through environmental education. Moreover, incorporating environmental education into learning processes helps students develop critical thinking skills, enabling them to approach environmental challenges with more significant analytical depth and selectivity. Indonesia's knowledge achievement can be compared with that of China and Germany. China demonstrated that the Green School program strengthens students' ecological literacy through the integration of national policies [14]. This approach emphasizes cognitive mastery through curriculum and government regulations. Meanwhile, Germany states that Education for Sustainable Development (ESD) is oriented towards development based on direct experience, for example, the Schools 4 Future program, through student activities in examining energy use and calculating carbon footprints, emphasizes direct experience and a participatory approach [15].

Differences in school achievement across indicators of caring, practical competency, and knowledge can be seen through the environmental culture developed in each country's schools. Schools with an environmental culture have the potential to foster caring awareness in students through collective norms, values, and habits that encourage pro-environmental behavior. Practical competency indicators are more prominent in schools with infrastructure such as recycling facilities, green spaces, integrated waste management facilities, laboratories, and optimal resources. Meanwhile, knowledge indicators are generally higher in schools that integrate environmental education into the formal curriculum, embracing

visionary leadership and encouraging learning innovation. Ecological literacy is not solely a student achievement but is closely related to school culture, the availability of adequate resources, and leadership contributions to the implementation of sustainability strategies. This study has several limitations related to the location and subjects used, making the findings not fully generalizable to schools with different characteristics. The variables are also limited to measuring caring, practical competency, and knowledge, while contextual variables including student motivation, family participation, school infrastructure, and sociocultural norms have not been studied in depth. Further research is recommended to expand the subject, add variations in variables, and explore contextual variables that impact the achievement of ecological literacy to obtain comprehensive and applicable results.

## 4 Conclusion

Research findings demonstrate that the Adiwiyata program effectively integrates environmental education across participating schools. Adiwiyata Schools in Pati Regency implement diverse activities to operationalize the program, including: (a) incorporating environmental education into academic subjects through project-based learning focused on plastic waste recycling, (b) conducting tree planting initiatives through the "Green Planet Project", (c) maintaining school environmental cleanliness via the "Clean Campus Project", and (d) implementing community river cleaning through the "Clean River Project". The study reveals that students' ecological literacy achieved high performance across all three dimensions: caring, practical competency, and knowledge aspects. These results show that the various activities in the Adiwiyata program effectively build strong environmental awareness among students. The program's success demonstrates that it can serve as a practical model for other schools seeking to enhance environmental education and address climate change issues.

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## References

1. N. A. Wibowo, S. Sumarmi, S. Utaya, S. Bachri, and Y. Kodama, "Students' Environmental Care Attitude: A Study at Adiwiyata Public High School Based on the New Ecological Paradigm (NEP)," *Sustain.*, vol. 15, no. 11, 2023, doi: 10.3390/su15118651.
2. C. Wittlich, L. MönTer, and H. Lathan, "Planetary Health and Education for Sustainable Development: An Integrative Approach with Focus on Climate Change-related Human Health Risks and Their Thematisation in School Contexts," *J. Educ. Sustain. Dev.*, vol. 17, no. 2, pp. 200–217, 2023, doi: 10.1177/09734082241238087.
3. D. Petkou, A. Kounani, M. Tsiouni, and E. Afedoulidou, "Can Sustainable Schools Influence Environmental Consciousness and Behavior in Early Childhood? The Perspectives of Early Childhood Educators," *Educ. Sci.*, vol. 15, no. 7, pp. 1–20, 2025, doi: 10.3390/educsci15070916.
4. P. João, P. Sá, M. H. Henriques, and A. V. Rodrigues, "Sustainable Development in Basic Education Sciences in Portugal—Perspective of Official Curriculum Documents,"

- Sustain.*, vol. 14, no. 9, 2022, doi: 10.3390/su14095651.
5. M. Cernicova-Buca, G. M. Dragomir, V. Gherheș, and A. Palea, “Students’ Awareness Regarding Environment Protection in Campus Life: Evidence from Romania,” *Sustain.*, vol. 15, no. 23, pp. 1–18, 2023, doi: 10.3390/su152316444.
  6. K. Velepini, “Assessing the Role of Environmental Education Practices Towards the Attainment of the 2030 Sustainable Development Goals,” *Sustain.*, vol. 17, no. 5, pp. 1–20, 2025, doi: 10.3390/su17052043.
  7. A. A. Akinsemolu and H. Onyeaka, “The role of green education in achieving the sustainable development goals: A review,” *Renew. Sustain. Energy Rev.*, vol. 210, no. August 2024, p. 115239, 2025, doi: 10.1016/j.rser.2024.115239.
  8. R. Sánchez-García and S. Reyes-de-Cózar, “Enhancing Project-Based Learning: A Framework for Optimizing Structural Design and Implementation—A Systematic Review with a Sustainable Focus,” *Sustain.*, vol. 17, no. 11, pp. 1–24, 2025, doi: 10.3390/su17114978.
  9. S. L. Colombo, S. G. Chiarella, C. Lefrançois, J. Fradin, A. Raffone, and L. Simione, “Why Knowing about Climate Change Is Not Enough to Change: A Perspective Paper on the Factors Explaining the Environmental Knowledge-Action Gap,” *Sustainability*, vol. 15, no. 20, p. 14859, 2023, doi: 10.3390/su152014859.
  10. Y. S. Lee, A. Rashidi, A. Talei, H. J. Beh, and S. Rashidi, “A Comparison Study on the Learning Effectiveness of Construction Training Scenarios in a Virtual Reality Environment,” *Virtual Worlds*, vol. 2, no. 1, pp. 36–52, 2023, doi: 10.3390/virtualworlds2010003.
  11. A. Djirong, K. Jayadi, A. Abduh, A. Mutolib, R. F. Mustofa, and A. Rahmat, “Assessment of Student Awareness and Application of Eco-Friendly Curriculum and Technologies in Indonesian Higher Education for Supporting Sustainable Development Goals (SDGs): A Case Study on Environmental Challenges,” *Indones. J. Sci. Technol.*, vol. 9, no. 3, pp. 657–678, 2024, doi: 10.17509/ijost.v9i3.74385.
  12. Sumarmi *et al.*, “Implementing the OBE Model in Plastic Waste Management Using the 4R EPR Pattern for Green Campus,” *Int. J. Environ. Impacts*, vol. 7, no. 3, pp. 455–473, 2024, doi: 10.18280/ije.070308.
  13. C. Chen, Q. An, L. Zheng, and C. Guan, “Sustainability Literacy: Assessment of Knowingness, Attitude and Behavior Regarding Sustainable Development among Students in China,” *Sustain.*, vol. 14, no. 9, 2022, doi: 10.3390/su14094886.
  14. X. Yuan *et al.*, “Promoting education for sustainable development through the green school program to achieve SDGs: Insights from a case study of Beijing’s primary and secondary schools,” *Int. J. Chinese Educ.*, vol. 13, no. 2, pp. 1–30, 2024, doi: 10.1177/2212585X241259192.
  15. O. Wagner, L. Tholen, S. Albert-Seifried, and J. Swagemakers, “Empowering Students to Create Climate-Friendly Schools,” *Energies*, vol. 17, no. 9, 2024, doi: 10.3390/en17092199.