Journal of Language and Literature Education (JoLaLE)
Volume 3, No 2 – Juni 2026
e-ISSN : 3046-7373

DEVELOPMENT OF DIGITAL TECHNOLOGY-BASED LEARNING MODEL AND GREEN HOUSE EDUCATION TO IMPROVE ENVIRONMENTAL LITERACY

Henny Prasetyani[1]*, Adi Nova Trisetiyanto[2], Dila Lailatus Sifak[3]
[1,2,3]Informatics Education Study Program, Faculty of Science and Technology, Universitas Ivet, Semarang, Indonesia
[1]hennyprasetyani@unisvet.ac.id
[2]adinova@unisvet.ac.id
[3]dilasyifa010604@gmail.com
* Coresponding Author

Received: 28-05- 2026	Revised: 03-6-2026	Approved: 25-06-2026

ABSTRACT

This study aims to develop a valid, practical, and effective learning model based on digital technology and Green House Education to improve students' environmental literacy. Low environmental literacy remains a prominent issue, necessitating learning innovations that foster decision-making and pro-environmental behavior. Using the Research and Development (R&D) method with the ADDIE approach (Analysis, Design, Development, Implementation, and Evaluation), this research produced the Digital Green House Learning (DGHL) model. The model integrates digital sensor-based greenhouse observations, data analysis, and green actions. Expert validation results showed the model is very valid, achieving an overall average of 81.85%. Practicality tests from teachers and students yielded an average of 80.18%. Furthermore, a paired sample t-test indicated a statistically significant environmental literacy improvement (p < 0.05). The DGHL model is highly effective, achieving an N-Gain score of 0.72 (high), significantly outperforming the control group (0.32). Conclusively, this model comprehensively enhances environmental literacy for sustainability.

***Keywords**: ADDIE model, digital technology, environmental literacy, green house, learning*

INTRODUCTION

The 21st century is characterized by the acceleration of information and communication technology, bringing significant changes to almost all aspects of life, including education. Today's students live in a digital era fraught with information; therefore, the ability to filter, process, and utilize information has become a crucial competency. On the other hand, the world is facing increasingly complex global environmental crises, ranging from air quality degradation and water pollution to the energy crisis. These two major challenges demand a learning model capable of addressing dual needs: equipping students with digital literacy while simultaneously improving environmental literacy.

The increasingly complex global environmental changes necessitate serious efforts to instill environmental awareness from an early age. Education plays a strategic role in shaping the environmentally friendly behavior of the younger generation, one of which is through the green education approach. This approach integrates sustainability values aimed at improving students' knowledge, skills, and attitudes so they can play an active role in protecting the environment [1]. However, empirical facts show that the environmental literacy of students in Indonesia is still relatively low. An OECD survey [2] revealed that although students have basic knowledge of environmental issues, the majority are unable to connect this knowledge with real actions in their daily lives. This aligns with the findings of Rijal *et al.* [3], stating that the environmental literacy of high school students in Indonesia remains in the moderate to low category.

Furthermore, the development of digital technology (Industrial Revolution 4.0) requires education to adapt to the digitalization of learning. Students, as digital natives, open up tremendous opportunities for interactive learning. However, the gap between digital literacy and environmental literacy remains quite substantial. A study by Kominfo [4] showed that the digital literacy level of the Indonesian public is in the moderate category, while the environmental literacy of high school students in making eco-friendly decisions is still notably low [5].

Several previous studies have developed technology-based learning models, such as the use of social media for blended learning [6] and remote control applications (AirDroid) to support effective distance learning [7]. Most of these studies focused on using technology for cognitive aspects, but few have specifically integrated digital technology with green education to transform environmentally caring attitudes and behaviors [8]. To strengthen the conceptual framework of this integration, the proposed model is grounded in Constructivism and Kolb's Experiential Learning Theory. Under these theoretical lenses, the use of Internet of Things (IoT) sensors within a greenhouse provides students with concrete experiences. By actively interacting with real-time ecological data, analyzing it, and reflecting on the outcomes, students construct their own meaningful understanding of environmental issues rather than passively receiving information. In fact, integrating both allows students to simultaneously develop digital and environmental literacy skills, which are essential 21st-century competencies [9]. The Indonesian government, through the *Kurikulum Merdeka* (Independent Curriculum), also encourages projects strengthening the Pancasila Student Profile, specifically in the environmental awareness dimension [10]. Therefore, research on the development of a learning model based on digital technology and green education is highly relevant to answering 21st-century educational challenges, offering novelty by combining educational technology innovation and environmental sustainability.

RESEARCH METHODS

This study utilizes the Research and Development (R&D) method, aiming to produce a digital technology and Green House Education-based learning model. The development model used is ADDIE, which includes the following stages: Analysis, Design, Development, Implementation, and Evaluation [11], [12]. Specifically, the Analysis stage involves identifying field needs, evaluating the curriculum, and assessing students' characteristics and their initial digital and environmental competencies. The Design stage focuses on formulating learning objectives, designing the Digital Green House Learning (DGHL) model syntax, and preparing the digital tools alongside the greenhouse activities. In the Development stage, the initial product is built and subjected to expert validation to ensure its feasibility. During the Implementation stage, the revised model is applied to students in real classroom and greenhouse settings. Finally, the Evaluation stage measures the overall practicality and effectiveness of the model in achieving the intended learning goals. A problem-solving approach is combined with green education principles, where students are trained to identify environmental issues, analyze data, and design solutions through the use of digital technology.

This research was conducted at SMK Muhammadiyah 03 Sukolilo, Pati, which has a school garden program. The research subjects were selected using a purposive sampling technique, chosen based on class equivalence and prior basic knowledge of the school's ecology program. The total sample consisted of 64 students, evenly divided into an experimental group (N = 32) and a control group (N = 32). The research instruments included observation sheets, validation questionnaires (for material experts, media experts, and learning experts) [13], environmental literacy tests (pretest and posttest), and interviews. The validation questionnaires utilized a Likert scale to assess the product's validity from various expert perspectives. To ensure methodological precision, the content validity from the expert evaluations was quantitatively calculated using Aiken's V formula to establish a robust validity index. Meanwhile, the observation sheets and interviews were used to gather qualitative data regarding the model's practicality from the viewpoints of both teachers and students. To measure the core dependent variable, the environmental literacy tests were specifically designed to cover four main dimensions: ecological knowledge, cognitive skills, caring attitudes, and pro-environmental behaviors.

The model's effectiveness in improving environmental literacy was quantitatively analyzed using the paired sample t-test and N-Gain test [14]. Before conducting the t-test, prerequisite tests consisting of normality and homogeneity tests were performed to ensure the data were normally distributed and homogeneous. The paired sample t-test aimed to determine whether there was a statistically significant difference between the students' environmental literacy scores before and after the intervention. Furthermore, the N-Gain test was applied to calculate the magnitude of the improvement, categorizing the effectiveness of the DGHL model into high, medium, or low criteria [14].

RESULTS AND DISCUSSION

Based on the needs analysis, the developed learning model, named Digital Green House Learning (DGHL), was designed by placing students as active subjects. This model consists of eight syntax stages: *Environmental Awareness*, *Digital Exploration*, *Green House Investigation*, *Digital Data Collection*, *Data Analysis*, *Environmental Problem Solving*, *Green Action*, and *Reflection & Digital Reporting*. The resulting products include a guidebook, digital modules [15], digital student worksheets (LKPD) [16], and environmental literacy instruments.

In this study, environmental literacy was developed into four main indicators used as references in the preparation of instruments and assessments, as presented in Table 1:

Table 1. Environmental Literacy Indicators

Dimension	Indicator
Knowledge	Understanding environmental concepts and issues
Skills	Identifying, collecting, and analyzing data
Attitude	Showing concern for the environment
Behavior	Taking real, eco-friendly actions

To assess the quality of the model from the Development stage, the validity analysis utilized the percentage category interpretation guidelines presented in Table 2:

Table 2. Validity Analysis Categories

Percentage	Category

81–100%	Very valid
61–80%	Valid
41–60%	Quite valid
21–40%	Less valid
0–20%	Invalid

Based on the product testing, the evaluation results of the model development—comprising expert validation, practicality tests for teachers and students, and environmental literacy effectiveness tests—can be seen in Tables 3, 4, and 5 below:

Table 3. Expert Validation Results

Validator	Assessed Aspects	Percentage	Category
Learning Expert	Model design and syntax	82,34 %	Very valid
Technology Expert	Digital media functionality	79,67 %	Valid
Environment Expert	Depth of ecological material	83,54 %	Very Valid
Average	**Overall Validity**	**81,85 %**	**Very Valid**

Based on Table 3, the expert validation results indicate that the DGHL model is categorized as "Very Valid" with an overall average of 81.85%. The environmental expert gave the highest score (83.54%), demonstrating that the ecological materials and greenhouse activities are highly relevant and accurate for addressing current environmental issues. The learning design and syntax also received a "Very Valid" rating (82.34%), proving that the problem-solving approach combined with green education is structurally and pedagogically sound. Meanwhile, the technology expert's validation yielded a "Valid" category (79.67%), indicating that the digital media functionality—including the digital modules and worksheets—is well-designed and suitable for student use, with minor technical refinements applied based on their constructive feedback.

Table 4. Practicality Test Results

Respondent	Assessment Aspect	Percentage	Category
Teacher	Ease of model implementation	81,52 %	Very valid
Student	Response to media & activities	78,83 %	Valid
Average	**Overall Validity**	**80,176 %**	**Valid**

Furthermore, the practicality test results presented in Table 4 show an overall average of 80.18%, falling into the "Valid" (or Practical) category. The teachers' assessment (81.52%) highlights that the model and its guidebook are highly practical and easy to implement in a real school environment without requiring overly complex technical preparations. The students' response (78.83%) confirms that they found the digital media, greenhouse investigations, and green actions to be engaging, accessible, and motivating.

Prior to evaluating the magnitude of the model's effectiveness, prerequisite statistical tests were conducted on the students' scores. The normality test using the

Journal of Language and Literature Education (JoLaLE)
Volume 3, No 2 – Juni 2026
e-ISSN : 3046-7373

Shapiro-Wilk method indicated that the data for both the experimental and control groups were normally distributed ($p > 0.05$). Furthermore, Levene's homogeneity test confirmed that the variances between groups were homogeneous ($p > 0.05$). Following these prerequisites, the paired sample t-test was administered to the experimental group (N = 32) to determine the significance of the learning intervention. The statistical results revealed a t-statistic of 14.85 with degrees of freedom (df) = 31 and a p-value of 0.000 ($p < 0.05$). This confirms a highly significant statistical difference in students' environmental literacy before and after the application of the DGHL model.

Table 5. Environmental Literacy Improvement Results

Group	Pretest Average	Posttest Average	N-Gain Score
Experiment	45,30	84,50	0,72
Control	44,80	62,40	0,32

Based on Table 5, it can be seen that the average pretest scores between the experimental group (45.30) and the control group (44.80) are not significantly different, indicating that the students' initial environmental literacy skills were relatively the same. After being treated with the Digital Green House Learning (DGHL) model, the average posttest score of the experimental group increased significantly to 84.50, while the control group using conventional learning only reached 62.40. The results of the N-Gain analysis show that the experimental group obtained a score of 0.72, which falls into the High or Effective category. Meanwhile, the control group only obtained an N-Gain score of 0.32, which is in the Medium category. This proves that the use of the digital technology-based DGHL model is significantly more effective in improving students' environmental literacy compared to the conventional learning model.

The research results based on the aforementioned trials indicate that the integration of digital technology and greenhouses provides a contextual learning environment based on local science [17]. The use of Internet of Things (IoT) sensors in the *Green House Investigation* and *Digital Data Collection* stages significantly increased students' interactivity and accuracy in collecting real-time environmental data [18], [19]. This proved capable of triggering students' curiosity to discover solutions to surrounding environmental problems.

The success in improving environmental literacy, encompassing dimensions from knowledge to behavior, aligns with the principle of sustainability competence. Students do not merely memorize theories; they are also capable of formulating decisions based on real ecological values [20]. Furthermore, the application of the *Green Action* stage empirically proves that direct experience is essential for fostering pro-environmental behavior that has a long-term impact [21], [22]. Learning using greenhouse facilities has been proven to optimize ecological literacy far more effectively than passive conventional classroom learning [23]. This strengthens the argument that systematic instructional design, such as ADDIE, can maximally synergize environmental pedagogy and technological innovation [24].

CONCLUSION

The development of a learning model based on digital technology and Green House Education is proven to be highly relevant to 21st-century demands. Through the systematic ADDIE approach, this research has successfully produced the Digital Green

House Learning (DGHL) model, which fully integrates digital learning activities with ecological investigations in the greenhouse. Expert validation and field implementation results indicate that this model is not only valid and practical but also highly effective in fostering conceptual understanding, caring attitudes, and real eco-friendly actions that are measurable (via N-Gain). This model is expected to serve as a solution-oriented alternative reference for preparing a digital native generation that is not only technologically smart but also cares about the preservation of the living environment. However, this study is limited by its relatively small sample size and its specific implementation in a single vocational school equipped with pre-existing greenhouse facilities. Therefore, future research is recommended to adapt and test the DGHL model across different educational levels and broader school contexts, including those without established green infrastructure, to further validate its generalizability and scalability.

DAFTAR PUSTAKA

[1] A. A. Akinsemolu and H. Onyeaka, "The role of green education in achieving the sustainable development goals: A review," Mar. 01, 2025, *Elsevier Ltd*. doi: 10.1016/j.rser.2024.115239.

[2] *PISA 2018 Assessment and Analytical Framework*. in PISA. OECD, 2019. doi: 10.1787/b25efab8-en.

[3] A. S. Rijal, A. Rasyid, E. Dewi Jannati, P. P. Biologi, and A. History, "PEDAGOGI BIOLOGI Analisis Literasi Lingkungan Siswa Menengah Atas: Literature Review ARTICLE INFO ABSTRAK," *Jurnal Pedagogi Biologi (JPB*, p. 9, 2025, [Online]. Available: https://ejournal.unma.ac.id/index.php/bp/

[4] Kominfo, "Status Literasi Digital di Indonesia 2021," 2021.

[5] R. Nasution, "Analisis Kemampuan Literasi Lingkungan Siswa SMA Kelas X di Samboja dalam Pembelajaran Biologi," 2016.

[6] A. N. Amiruddin, N. H. A. Huzaimi, M. Mohamad, and M. F. Ani, "Challenges and Benefits of Blended Learning on Tertiary Education ESL Classrooms: A Literature Review," *Creat. Educ.*, vol. 13, no. 11, pp. 3715–3730, 2022, doi: 10.4236/ce.2022.1311235.

[7] H. Prasetyani and D. N. Cahyani, "Pengembangan Model Pembelajaran Jarak Jauh dengan Control Device Memanfaatkan Aplikasi AirDroid," *Edumatic : Jurnal Pendidikan Informatika*, vol. 6, no. 1, pp. 11–20, 2022, doi: 10.29408/edumatic.v6i1.5026.

[8] A. Rahardjanto, T. Indria Permana, and A. Adnan Mohd Shukri, "Integration of Digital Technologies in Environmental Education: A Systematic Review of Trends, Impacts, and Future Directions," vol. 37, no. 1, pp. 30–47, 2025, doi: 10.23917/varidika.v37i1.9908.

[9] UNESCO, *Education for Sustainable Development Goals: learning objectives*. UNESCO, 2017. doi: 10.54675/CGBA9153.

[10] Kemendikbud, *Tahapan Implementasi Kurikulum Merdeka di Satuan Pendidikan*. 2022.

[11] Zamsiswaya and Syawaluddin, "Pengembangan Model ADDIE (Analisys, Design, Development, Implemetation, Evaluation)," *Jurnal Pendidikan Tambusai*, vol. 8, no. 3, pp. 46363–46369, 2024.

[12] M. A. Adeoye, K. A. S. I. Wirawan, M. S. S. Pradnyani, and N. I. Septiarini, "Revolutionizing Education: Unleashing the Power of the ADDIE Model for Effective Teaching and Learning," *JPI (Jurnal Pendidikan Indonesia)*, vol. 13, no. 1,

pp. 202–209, Apr. 2024, doi: 10.23887/jpiundiksha.v13i1.68624.

[13] D. Untoroseto and A. Triayudi, "Analysis of Blended Learning Development in Distance Learning in Variation of Borg & Gall and Addie Models," *Journal La Multiapp*, vol. 4, no. 6, pp. 231–242, Dec. 2023, doi: 10.37899/journallamultiapp.v4i6.973.

[14] R. R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," 1998.

[15] H. Isfahani, S. Hutasuhut, and Z. Siregar, "Ekuitas: Jurnal Pendidikan Ekonomi Pengembangan Bahan Ajar Digital Berbasis PBL untuk Meningkatkan Hasil Belajar Ekonomi Siswa," vol. 11, no. 2, pp. 367–377, 2023, [Online]. Available: https://ejournal.undiksha.ac.id/index.php/EKU

[16] A. Jauhari, F. D. Puspita, I. A. Rizki, S. Sujito, and N. A. Lestari, "Interactive Physics Modular (IPM): The development of website-based learning media using a problem-based learning model and a STEM-ESD approach to enhance environmental literacy in temperature and heat topics," *Journal of Environment and Sustainability Education*, vol. 4, no. 2, pp. 355–365, Jun. 2026, doi: 10.62672/joease.v4i2.206.

[17] M. I. Abdullah, J. Kusuma, and R. N. Abrar, "Enhancing Middle School Students' Scientific Literacy Through Inquiry-Based Learning In Environmental Education," *Journal of Science and Mathematics Education*, vol. 1, no. 4, pp. 111–117, Dec. 2025, doi: 10.70716/josme.v1i4.338.

[18] D. Tsipianitis, A. Misirli, and V. Komis, "Internet of Things in education: A review," 2024.

[19] B. Tabuenca, J. L. Moreno-Sancho, J. Arquero-Gallego, W. Greller, and D. Hernández-Leo, "Generating an environmental awareness system for learning using IoT technology," *Internet of Things (Netherlands)*, vol. 22, Jul. 2023, doi: 10.1016/j.iot.2023.100756.

[20] A. E. J. Wals, "Mirroring, Gestaltswitching and transformative social learning: Stepping stones for developing sustainability competence," *International Journal of Sustainability in Higher Education*, vol. 11, no. 4, pp. 380–390, 2010, doi: 10.1108/14676371011077595.

[21] B. J. Alvarado and M. P. Garcia, "Environmental Literacy and Pro-environmental Practices: A Correlational Study of Senior High School Students in Davao Occidental," *Asian Journal of Education and Social Studies*, vol. 52, no. 6, pp. 315–326, May 2026, doi: 10.9734/ajess/2026/v52i63097.

[22] M. Yusup and M. Ariska, "STRATEGI DALAM GREEN EDUCATION UNTUK MELAHIRKAN MANUSIA DENGAN GREEN BEHAVIOR," 2025.

[23] atus Sholihah, E. Nurul Malahayati, and L. Nararia Kusuma, "Improving Environmental Literacy in Experiential Learning E-Modules in Biology Subjects," 2025.

[24] P. Biologi *et al.*, "PENGEMBANGAN LEMBAR KERJA PESERTA DIDIK ELEKTRONIK (E-LKPD) BERBASIS ETNOPEDAGOGI UNTUK MELATIHKAN LITERASI SAINS SISWA KELAS X MATERI EKOSISTEM Development of Electronic Student Worksheets (E-LKPD) Based On Ethnopedagogy to Train the Science Literacy of Grade X Students on Ecosystem Material Dicky Reza Ferlyano," 2026. [Online]. Available: https://ejournal.unesa.ac.id/index.php/bioedu