Interactive Nearpod: Student science literacy on the topic of global warming

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Abstract
The low level of science literacy among Indonesian students, as indicated by the results of the Programme for International Student Assessment, calls for the development of innovative and contextual teaching materials. This study aims to develop an interactive e-module using Nearpod on the topic of global warming and to determine its validity and practicality in improving the science literacy of junior high school students. The study used the Research and Development method with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), involving 31 seventh-grade students and 1 science teacher as subjects in a limited pilot test. Data were collected through expert validation questionnaires, teacher and student response questionnaires, and a science literacy test, then analyzed using descriptive statistics, the Wilcoxon signed-rank test, and the N-Gain test. The results showed that the e-module was deemed highly suitable, with an average expert validity of 89.58%, an excellent response rate from teachers (90.62%), and an N-Gain of 0.8446, which is categorized as high. These findings indicate that the Nearpod-assisted interactive e-module is a viable alternative science teaching material that supports the enhancement of students' science and environmental literacy.

1. Introduction

Education in the 21st century demands changes in the educational system that are adaptive to advances in information and communication technology (Supiandi & Lisa, 2018). Educational technology plays a crucial role in fostering independent learning to improve the quality of education during the Fourth Industrial Revolution (Gustini et al., 2023), while also equipping students to face global challenges characterized by an abundance of information and interdisciplinary issues (Prihatiningtyas et al., 2025). One of the essential 21st-century skills that needs to be developed through education is science literacy (Luthfiana et al., 2023), the ability to connect scientific knowledge with daily life based on valid evidence and facts to solve problems and make decisions (Firdausy & Prasetyo, 2020). Science literacy is not merely the mastery of facts, but rather the competence to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically (Sahyar et al., 2020). Thus, low science literacy is not merely an academic issue, but an indication of a crisis in human resource readiness to face evidence-based challenges in the future.

The science literacy levels of Indonesian students still face serious challenges. According to the results of the 2022 Program for International Student Assessment (PISA), Indonesia scored 383, 102 points below the OECD average of 485 points and ranked 69th out of 81 countries (OECD, 2023a). This gap indicates that some students are unable to apply scientific knowledge to solve everyday problems, which is at the core of science literacy (Herlina & Abidin, 2024). Low science literacy is influenced by various factors, ranging from the curriculum, teaching strategies, and instructional models to the learning resources used (Hidayat et al., 2021). One of the main causes of this problem is instructional materials that are text-heavy, monotonous, and fail to integrate digital technology, making it difficult for students to deeply comprehend scientific thinking and relate it to real-world contexts (Herlina & Abidin, 2024).

The gap between science literacy requirements and the still-conventional state of science education is clearly evident in the teaching of global warming. This topic involves abstract concepts such as the greenhouse effect and climate change, which are difficult to observe directly in the classroom; thus, it requires teaching materials capable of visualizing these phenomena so that students can easily understand them (Jannati et al., 2018). Based on initial observations at a public junior high school, science instruction relied solely on textbooks without additional interactive teaching materials, causing students to tend to be passive and struggle to connect what they were learning to their surrounding environment. These conditions underscore the need for contextual, interactive, and science-activity-based teaching materials that actively engage students.

Studies have shown that interactive e-modules can effectively boost student' science knowledge and learning results, as seen through high N-Gain scores (Astriawati & Djukri, 2019). Also, the Nearpod platform has been found to increase student involvement, interest, and academic performance (Mufassaroh et al., 2025).

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Nearpod is a platform that uses sounds, pictures, and mix of both to make learning more engaging. It lets teachers add videos, interactive simulations, and visual tools to help student better understand what they are learning (Mufassaroh et al., 2025). Using Nearpod-supported e-modules has been said to make learning more fun by including animated videos, pictures, and text. This helps students ask more questions and show more interest in the material (Feri & Zulherman, 2021). Nearpod's interactive tools like Open-Ended Questions, the Collaborate Board, and simulations are closely connected to important aspects of science literacy, which makes them useful for creating e-modules (Amelia et al., 2024; Bintoro et al., 2024). Howecer, there is very little research that combiner Nearpod-supportes e-modules with the seven indicators of science and environmental literacy skills as defines by the PISA 2025 framework, especially when it comes to teaching global warming at the junior high school level. This makes the current study a new and important contribution to the field.

In response to the issue of static instructional materials, interactive e-modules have emerged as an effective solution to address the limitations of conventional textbooks (Maison et al., 2025). E-modules enable self-directed learning that can be accessed anywhere and anytime, and they can integrate various media such as videos, simulations, and visual content to facilitate the understanding of complex concepts (Firdausy & Prasetyo, 2020). Among the various available development platforms, Nearpod was selected for this study because it combines audio, visual, and audiovisual elements into a single unit that enables students to understand abstract concepts such as global warming (Mufassaroh et al., 2025).

Various learning media have been developed to address the limitations of conventional teaching materials in fostering science literacy, such as digital flipbook-based e-modules that help students develop their scientific knowledge, competencies, and contextual understanding in an integrated manner (Humairah et al., 2024), virtual laboratories that train students to ask questions and conduct experiments independently (Abdjul et al., 2024), and Articulate Storyline-based media that help explain difficult concepts in a more engaging way (Ramadhani & Asrul, 2024). All three share a common orientation: promoting active engagement, scientific reasoning, and evidence-based information processing, which are at the core of science literacy. However, these media generally still focus on strengthening general cognitive science competencies and have not yet been explicitly mapped to the more detailed science and environmental science literacy indicators as formulated in the PISA 2025 framework. It is this gap that distinguishes this study from previous research: the design of an e-module that systematically maps each interactive feature of Nearpod to the seven indicators of science and environmental science literacy competencies within a single unit on global warming.

Based on the discussion above, this study has two main goals (1) it aims to create an interactive e-module on global warming that uses Nearpod to help student improve their scientific literacy, and (2) it wants to chech if this e-module is valid and practical for helping students better understand global warming through science literacy.

2. Method

This study used the Research and Development (R&D) method based on the ADDIE model, which stands for Analyze, Design, Development, Implementation, and Evaluation (Branch, 2009), as illustrated in Figure 1 below.

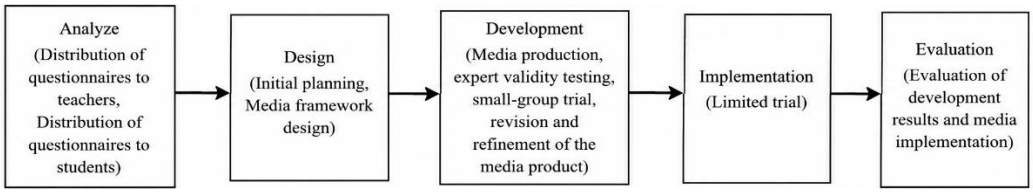


Figure 1. Stages of the ADDIE Model

The study included 31 seventh-grade student and one science teacher, chosen through convenience sampling (Golzar & Tajik, 2022). Data was gathered using questionnaires, teste, and documentation. The research tools used were questionnaires to gather information about the needs of teachers and student, questionnaires for experts in the subject matter, media, and language to validate the work, science literacy assessments in the form of tests given before and after the study, and questionnaires to collect responses from both teachers and students. Data analysis was done using descriptive analysis, reliability tests, difficulty level tests, discriminant power tests, the Wilcoxon test, and the N-Gain test.

3. Results and Discussion

The discussion of these research findings is organized around two research questions: (1) How is the process of developing Nearpod-assisted interactive e-modules on global warming designed to improve junior high school students' science literacy, and (2) What is the validity and practicality of the Nearpod-assisted interactive e-modules that were developed?

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3.1. The Development Process of Nearpod-Assisted Interactive E-Modules

The development of Nearpod-assisted interactive e-modules was carried out using the five-stage ADDIE model. During the analysis stage, the results of the needs assessment survey revealed that teachers had never utilized Nearpod-assisted interactive e-modules and had not yet delved deeply into the concept of science literacy, while students relied solely on textbooks without any additional interactive teaching materials. This situation aligns with the findings of Wulandari & Rachmadiarti (2025), who noted that students' low levels of science literacy are influenced by the lack of technology integration in learning. Curriculum analysis confirmed that the topic of global warming is relevant to science literacy because it involves scientific phenomena observable in everyday life; therefore, the material was divided into five subtopics: the greenhouse effect, causes, processes, impacts, and solutions to global warming.

During the design phase, learning outcomes and objectives were developed, along with a lesson flowchart, a storyboard, and pre-test and post-test instruments consisting of 14 items that measure 7 indicators of science and environmental literacy. Six Nearpod features were selected based on their relevance to the targeted competency indicators: Open-Ended Questions, Interactive Videos, Collaborate Board, Draw It!, Fill the Blank, and PhET Simulations. The selection of the Nearpod platform was based on its ability to integrate various interactive elements such as videos, quizzes, and questions, into a single module that can be used both synchronously and asynchronously (Pebriyanti et al., 2025).

During the development phase, the design was transformed into a tangible product using the Nearpod platform, which incorporated text, photos, graphics, videos, and interactive quizzes. The product was then validated by subject matter, media, and language experts, revised based on the validators' feedback, and pilot-tested in a small class of 10 students, yielding an excellent response rate (97.08%). During the implementation phase, a limited pilot test was conducted with 31 seventh-grade students over two sessions using the e-module. During the evaluation phase, formative evaluations were conducted at each stage, and a summative evaluation was carried out at the conclusion of the implementation based on expert validation results, user feedback, and pre-test-post-test data, all of which were used to refine the final product. The selection of the ADDIE model in this study was based on its systematic nature, such that each stage gradually improves the quality of the product based on evaluations from the previous stage (Siregar & Rhamayanti, 2025).

Several improvements were made based on expert input and the results of small-class pilot tests before the e-modules were used in a limited pilot. Subject matter experts recommended adding citations and a bibliography to each presented topic, aligning learning objectives with the content and questions, and including instructions on how to interpret graphs. Media experts recommended adding clearer instructions for student activities in each task, while the results of the small-class pilot revealed that students had difficulty accessing the Nearpod platform for the first time, so instructions on how to use the platform were added. All of this feedback was addressed as the basis for refining the product before the implementation phase, in line with the principle of continuous formative evaluation in the ADDIE model, which positions revision as an integral part of every development stage (Shakeel et al., 2023).

3.2. Validity and Practicality of Nearpod-Assisted Interactive E-Modules

The validation results from six experts confirm that the Nearpod-assisted interactive e-modules fall into the "highly feasible" category, as shown in Table 1.

Table 1. Summary of Validation Results for Interactive E-Modules by Experts

Validation Aspect	Percentage	Criteria
Material	89.58%	Very Worthy
Media	87.50%	Very Worthy
Language	91.67%	Very Worthy
Overall Average	89.58%	Very Worthy

The high level of content validation indicates the developers' success in integrating the concept of global warming accurately and contextually into students' lives, in line with the view that science content linked to socio-scientific issues is better able to develop students' science literacy in an authentic way (Holbrook & Rannikmae, 2009). The validation of the media aspect indicates that the Nearpod platform was successfully utilized to its full potential as an interactive learning medium (Perez, 2017), particularly in terms of accessibility and the ability to monitor student participation in real time (Armayanti & Prayogo, 2026). Validation of the language aspect, which received the highest percentage, indicates that the e-module uses language that is appropriate and commensurate with the developmental level of junior high school students, thereby minimizing the potential for misconceptions.

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The practicality of the e-module was measured through teacher and student feedback. The teacher feedback questionnaire yielded a score of 90.62%, classified as "very good," with no individual item scores below 75%. Student feedback in the small-class pilot reached 97.08% ("very good"), while the limited pilot with 31 students reached 82.79% ("very good"). The decrease in the percentage in the larger-scale trial is considered reasonable, given the greater heterogeneity in students' digital skills and experiences within the larger group (Walan, 2020). The ease of use of the e-module received the lowest percentage in both trials, which served as the basis for a revision involving the addition of a user guide for the Nearpod platform.

3.3. Analysis of How Using E-Modules Impacts Science Literacy

A Shapiro-Wilk test was done to check if the mean scores from the pre-test and post-test data are normally distributed. The normality test results showed significant values of 0.006 for the pre-test and 0.000 for the post-test. So, the average scores from the pre-test and post-test didn't follow a normal distribution because the -values were less than 0.05. So, the analysis to check how using Nearpod-assisted interactive e-modules affects students' science literacy kept using a nonparametric test called the Wilcoxon signed-rank test, and the result was Asymp. Sig.(2-tailed) < 0.000. the Wilcoxon test results show there is a big difference between the scores before and after the test, because the significance level is below 0.05. Using interactive e-modules with Nearpod helps improve students' understanding of science.

3.4. Improvement in Students' Science Literacy

The increase in student' understanding of science was checked by giving them tests before and after the study, which included 31 students. The N-Gain test was used to measure how much science literacy improved. The results of the N-Gain test are shown in Table 2.

Table 2. Statistics on Pre-test and Post-test Results and the N-Gain Test

Statistic	Pre-test	Post-test
Score Average	76.50	96.31
Minimum Score	50.00	64.29
Maximum Score	92.86	100.00
N-Gain Average	-	0.8446 (high)

The N-gain score is 0.8446, which is considered high. The average score went up from 76.50 before the test to 96.31 after the test. Out of the 31 students, 25 got a high N-Gain score, which is 80.65%, and 3 students each had moderate and low scores, which is 9.68% each, as shown in Figure 2 below.

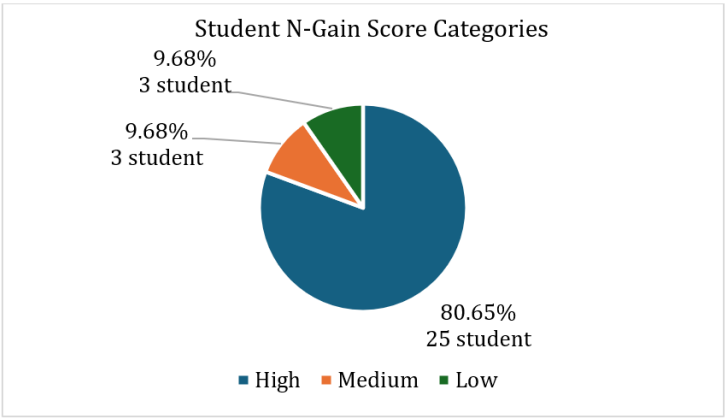


Figure 2. Student N-Gain Score Categories

The PISA 2025 framework includes three science literacy skills: explaining scientific phenomena (LS 1), designing and assessing scientific studies and interpreting data critically (LS 2), and using scientific information to research, evaluate, and make decisions (LS 3). It also adds an environmental science part that looks at how students can take action to address environmental and social issues in the current time period called the Anthropocene era (OECD, 2023b; White et al., 2023). Environmental science indicators cover explaining how human actions affect Earth systems (IL 1), making smart decisions by looking at different kinds of evidence and using creative and organized thinking to help protect and keep the environment healthy (IL 2), showing respect for different points of view and goals when working on problems that affect both society and the environment (IL 3), and Anthropocene agency (IL 4). The percentage of achievement for science and environmental science literacy indicators on the pre-test and post-tests are shown in Figure 3 below.

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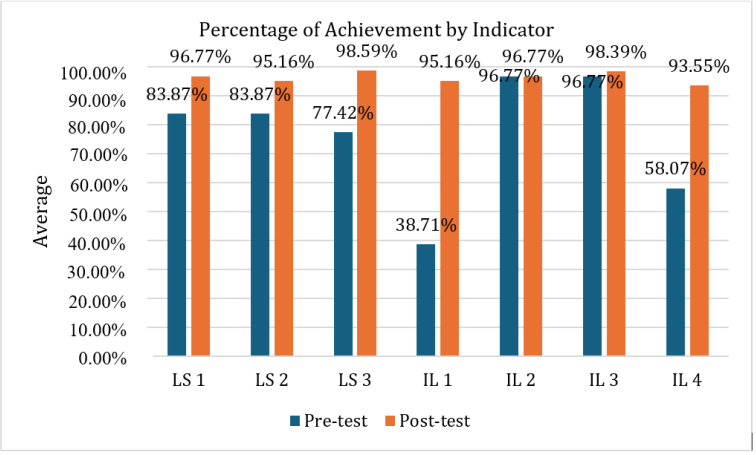


Figure 3. Percentage of Achievement by Science and Environmental Science Literacy Indicator

Analysis by indicator revealed patterns that are pedagogically significant. Indicator IL 1 had the lowest pre-test score (38.71%), but showed the greatest improvement, rising to 95.16% on the post-test. These findings indicate that although students were already familiar with the term "global warming," their understanding of the cause-and-effect mechanisms between human activities and changes in the Earth's system remained weak before using the e-module, and the e-module proved effective in bridging that gap through animated videos, simulations, and instructional materials. In contrast, indicators IL 2 and IL 3 showed high pre-test scores (96.77%), resulting in a relatively small increase on the post-test due to a ceiling effect, meaning the initial scores were already close to the maximum score, leaving little room for significant further improvement (Aisyah & Novita, 2025). Indicator LS 3 showed the second-largest improvement, rising from the lowest pre-test score among the three science literacy indicators 77.42% to 98.39% on the post-test, in line with the e-module's design, which integrates data from reliable scientific sources along with reflective questions that train students to discern valid information, a feature that is highly relevant given that the issue of global warming is prone to misinformation in the digital age.

Competency LS 1 requires students to recall and apply scientific knowledge, translate between different forms of representation, and construct and evaluate explanatory models of real-world phenomena (OECD, 2023b). In the global warming unit, this competency is demonstrated through students' ability to explain the mechanisms of the greenhouse effect in a logical sequence, starting from the absorption of solar radiation to the role of greenhouse gases in trapping heat. The LS 1 indicator achieved a relatively high pre-test score (83.87%), indicating that students already possessed some prior knowledge gained through mass media exposure and previous learning, and increased to 96.77% on the post-test, though the increase was relatively small due to the ceiling effect, confirming that the e-module successfully reinforced this competency, particularly in more complex contexts.

Competency LS 2 requires students to evaluate data collection methods and interpret data representations quickly. The improvement in LS 2 competency rose from 83.87% on the pre-test to 95.16% on the post-test. This improvement is significant because it requires higher evaluative cognitive skills compared to the pre-test questions, thus reflecting a genuine development in students' abilities rather than mere repetition. LS 3 competency is relevant to the topic of global warming, which is frequently subject to misinformation on social media. Competency LS 3 recorded a pre-test score of 77.42%, which then increased significantly after the use of the e-module, reaching 98.39% on the post-test. This indicates that the e-module is most effective at developing the competency that students struggled with the most prior to the intervention, consistent with the e-module's design, which integrates content with reflective questions that train students to select valid information.

Environmental literacy is a new construct within the PISA 2025 framework that measures young people's knowledge, concerns, and capacity to act on environmental issues, known as "Agency in the Anthropocene" (White et al., 2023). IL Indicator 1 had a pre-test score of 38.71%, reflecting a gap where students were familiar with the terms but did not yet understand the cause-and-effect logic, before increasing dramatically to 95.16% on the post-test. IL Indicator 2 achieved a pre-test score of 96.77% due to answer patterns that were relatively clear from a common-sense perspective; consequently, the post-test showed no significant room for improvement (ceiling effect), not because the e-module was ineffective. IL Indicator 3 recorded a pre-test score of 96.77%, which increased slightly to 98.39% on the post-test, consistent with findings that middle school-aged students generally already exhibit a tendency toward inclusive values through socialization and character education (White et al., 2023). IL Indicator 4, which reflects students' capacity to act tangibly as agents of environmental change, showed a pre-test achievement of 58.06%, which increased to 93.55% on the post-test, confirming that this indicator does not stem solely from rote memorization of concepts but requires exposure

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to real-world contexts, empirical data, and reflective questions that link scientific knowledge to students' personal responsibilities.

Global warming is a multidisciplinary scientific phenomenon that integrates concepts from physics, chemistry, biology, and earth sciences. This section examines the topic of global warming from its conceptual foundations to mitigation strategies, as presented in the e-module. Natural processes maintain Earth's surface temperature within a range that supports life, but this becomes a serious problem when these processes are excessively amplified by human activities. The greenhouse effect occurs as a result of natural processes, such as volcanic eruptions and earthquakes, or it can be a consequence of human activities (anthropogenic greenhouse effect) (Karwacka, 2025).

The core mechanism of the greenhouse effect occurs through the interaction of infrared photons with greenhouse gas (GHG) molecules (Filonchyk et al., 2024). Infrared photons absorbed by greenhouse gas molecules trigger vibrational and rotational motion in molecules such as CO_2, CH_4, and N_2O. Molecules that have absorbed energy then re-emit that energy in all directions, including downward (back toward Earth's surface), thereby trapping heat near the surface and causing an increase in Earth's average temperature (Filonchyk et al., 2024). Without the natural greenhouse effect, Earth's average temperature is estimated to be -18°C, well below the freezing point of water, making life as we know it impossible. The greenhouse effect is a problem not because of the phenomenon itself, but because of its increasing intensity due to rising greenhouse gas concentrations.

The section on the causes of global warming in the e-module presents GHG emissions data from various sectors of human activity through open-ended questions that encourage students to analyze each sector's contribution and determine priorities for mitigation actions based on scientific data. According to Calvin et al. (2023), greenhouse gas emissions from human activities can be grouped into five main sectors, namely: 1) the energy sector, which includes the burning of fossil fuels for power generation and heating; 2) transportation, dominated by fossil-fuel-powered motor vehicles; 3) industry, including the production of steel, cement, and chemicals; 4) agriculture, forestry, and land use, including deforestation, rice farming, and livestock farming; and 5) buildings, through energy use for air conditioning and heating.

The process of global warming involves six mechanisms: 1) the release of greenhouse gases (GHGs) caused by human activities (primarily CO2 from the burning of fossil fuels, CH4 from livestock and landfills, and N2O from agriculture) into the atmosphere; 2) the increase in atmospheric GHG concentrations, which absorb and re-emit infrared radiation around the Earth; 3) a reduction in the Earth's ability to radiate infrared energy into space; 4) an energy imbalance on Earth, in which incoming energy from the Sun exceeds the energy radiated outward; 5) the accumulation of excess energy in the Earth system, primarily in the oceans (the oceans absorb >90% of the excess energy); and 6) manifestations such as a rise in global average temperature, changes in weather patterns, and various other chain reactions.

The e-module on the impacts of global warming utilizes two complementary features: the Collaborate Board, for collaboratively exploring these impacts from various perspectives, and Open-Ended Questions, for critically evaluating individual understanding based on scientific evidence. The IPCC (2023) states that human-induced climate change has caused widespread adverse impacts on nature and humanity, occurring faster than anticipated. The following are the main impacts presented in the e-module:

a. Melting polar ice and rising sea levels. Ice in Antarctica and Greenland is melting at an increasing rate. Global sea levels have risen by about 20 cm since 1900, with half of that increase occurring since 1993 (IPCC, 2023). This rise threatens small islands and coastal cities around the world.

b. Increased frequency and intensity of extreme weather events: Heat waves, droughts, major floods, and more intense storms are occurring more frequently.

c. Impacts on biodiversity: Climate change disrupts ecological balance, affects species distribution, and accelerates the risk of extinction (Bhat et al., 2024).

d. Ocean acidification: The oceans absorb approximately 25% of emitted CO_2, causing a decrease in ocean pH and endangering coral reef ecosystems and shelled organisms.

e. Impacts on human health. Rising temperatures expand the range of tropical diseases (malaria and dengue fever), increase the risk of respiratory infections from wildfires, and threaten food security through reduced agricultural productivity.

Solutions to global warming are the culmination of the entire e-module sequence, in which students are encouraged not only to understand the solutions conceptually but also to actively express, evaluate, and advocate for them. Solutions to global warming can be divided into two categories (Calvin et al., 2023). First,

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mitigation (preventing or reducing causes), which includes: 1) the energy transition from fossil fuels to renewable energy (solar, wind, hydro); 2) improving energy efficiency; 3) halting deforestation and promoting reforestation; 4) developing low-emission agriculture; 5) carbon capture and storage (CCS); and 6) adopting low-carbon lifestyles. Second, adaptation (adjusting to impacts that have already occurred or will occur) includes: 1) building climate-resilient infrastructure; 2) developing heat- and drought-tolerant crop varieties; 3) early warning systems for climate-related disasters; 4) designing climate-resilient cities; and 5) protecting coastal ecosystems.

4. Conclusion

An interactive e-module on global warming, developed using Nearpod, was successfully created using the ADDIE model and has proven to be feasible, practical, and effective in improving the science literacy of junior high school students. This is demonstrated by expert validity with an average of 89.58%, an increase in science literacy test scores from 76.49 to 96.31, and an N-Gain of 0.8446, which falls into the high category. Thus, the Nearpod-assisted interactive e-module on global warming is suitable as a valid, practical, and effective alternative science teaching material to strengthen the science and environmental literacy of junior high school students in accordance with the PISA 2025 framework.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Data Availability

The datasets generated during and/ or analysed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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