Eduproxima: Jurnal Ilmiah Pendidikan IPA
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CONTEXTUAL DIGITAL LEARNING MEDIA FOR ENVIRONMENTAL POLLUTION BASED ON STUDENTS' AND TEACHERS' NEEDS ASSESSMENT

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Article history:
Submitted: Dec. 31st, 2025; Revised: Feb. 03rd, 2026; Accepted: March 05th, 2026; Published: July 12th, 2026

ABSTRACT

Environmental pollution is a significant issue in environmental education because pollutants disrupt the balance of ecosystems. This condition requires educational approaches that foster students' environmental awareness and critical thinking skills. However, students' low competencies in addressing pollution-related problems indicate the need for innovative, relevant, and contextual learning media. This study aimed to analyze the need for learning media on environmental pollution topics at SMA Negeri 1 Polokarto. Data were collected using a 39-item Likert-scale questionnaire and open-ended questions involving 62 eleventh-grade students and three biology teachers. The data were analyzed using descriptive quantitative methods. The results showed that 17.70% of students perceived the material as difficult, 53% had never participated in practicum or observational activities, 24.20% reported limited influence on daily habits, and 38.70% considered the content insufficiently contextual. Regarding learning needs, 80.60% required practicum-based activities, 61.30% preferred interactive media, and 66.10% needed attractive illustrations. Additionally, 66.70% of teachers indicated a lack of innovative media and emphasized the importance of project-based and practicum-oriented learning. These findings highlight the urgency of developing context-based digital learning media to foster improved conceptual understanding and contextual problem-solving skills among students. The developed media will be pilot-tested to evaluate its effectiveness in students' environmental awareness and critical thinking.

Keywords: contextual; digital; environmental pollution; media

INTRODUCTION

The environment serves as the primary support system for human life. Therefore, somebody interested in sustainability must be cultivated from an early age. Individuals who understand the dangers of environmental degradation typically act with more responsibility (Verplanken, 2018). One of the most fundamental environmental problems is pollution. Since the industrial revolution, population expansion, urbanization, and the quick speed of industrialization have all become essential factors aggravating soil, water, and air pollution (Siddiqua *et al*., 2022). Various pollutants generated by these activities pose serious threats to ecosystem sustainability. A study by Xuan (2024) provides evidence that, between 2000 and 2023, pollution levels in Indonesia showed a consistent upward trend, consistent with population growth, economic development, and rising energy consumption. These facts underscore the critical importance of environmental education, which can foster environmental awareness and responsible, reflective thinking in addressing pollution-related problems.

OECD Data (2023) indicate that Indonesian students' environmental

awareness remains relatively low, with knowledge of climate change and global warming ranging from 50% to 70%. A study by Echazarra (2018) reported that although students' environmental knowledge increased from 57% to 64% between 2006 and 2015, their interest in caring about and seeking solutions to ecological problems declined. It is reflected in the finding that only 43% of 15-year-old students perceived the increase in greenhouse gas emissions as harmful, while the remaining students showed indifference. Individuals' critical thinking skills indirectly influence their ability to address environmental problems. In the context of PISA, this ability is reflected in literacy in reading, mathematics, and science. The PISA 2022 results reveal that Indonesian students' scientific literacy scores remain below the average of 81 participating countries, particularly in data analysis, argument evaluation, and the ability to connect scientific phenomena with real-life contexts (OECD, 2023). This is in line with the conditions at SMA N 1 Lembar in environmental pollution learning, which shows that students still have difficulty understanding the material well, especially in increasing their understanding and awareness of environmental conditions around them, so that more complete teaching materials are needed, along with learning activities based on facts in the field (Syamsussabri *et al.*, 2018). These conditions underscore the urgent need for learning strategies that can enhance both environmental awareness and critical thinking skills to support sustainable environmental stewardship in the future.

This situation highlights the challenges in teaching environmental pollution, a topic that inherently requires students to observe real-world phenomena, assess their impacts, and formulate appropriate solutions. However, classroom instruction often fails to connect learning materials with students' everyday experiences or to promote deep cognitive engagement. One contributing factor is the limited availability and use of effective learning media. Many schools still use passive, uninteractive traditional teaching materials like textbooks, student worksheets, and PowerPoint presentations (Kaniawati, 2017). Such media are often insufficient in linking conceptual content to authentic contexts or to students' interests (Dwipayana *et al*., 2020). Empirical findings also indicate that context-based audio-visual media resulted in a greater percentage of students achieving proficiency on critical thinking assessments compared to traditional methods (Sarwinda *et al*., 2020). Both teachers and students frequently report that the use of these media feels repetitive, unengaging, and less effective in raising motivation and deep conceptual understanding, particularly when compared to more dynamic, technology-based learning media (Anwari *et al*., 2023; Arigiati *et al*., 2021; Rosalina & Suhardi, 2020; Salzabila *et al*., 2025)

One essential component in preparing effective learning strategies is ensuring adequate facilities and infrastructure, particularly learning resources and instructional media (Budiman *et al*., 2022; Oktavia, 2022; Yudistira *et al*., 2021). Instructional media also provide significant benefits for teachers by facilitating the delivery of subject matter and motivating students to actively participate in the learning process (Dewantara *et al*., 2020). Furthermore, instructional media help clarify the presentation of learning content so that it is not conveyed solely through

verbal explanation, assist in overcoming limitations of space and time, provide opportunities for learners to engage in self-directed learning according to their abilities and interests, and promote a shared understanding of the learning material among students (Antari *et al*., 2019). The demand for interactive and work-based learning media has theoretical roots in constructivist and experiential theories. According to constructivist theory, knowledge is constructed by students through meaningful and engaging interaction; therefore, interactive multimedia encourages higher-order thinking skills, including analysis and problem-solving. Similarly, experiential learning emphasizes that firsthand experiences (i.e., observation and practicum activities) can facilitate the development of conceptual knowledge and reflective thinking. Experiential learning improves students' motivation and classroom engagement, focusing on developing abilities and experiences (Kong, 2021)

Instructional media function as tools through which educators convey learning material to their students (Feri & Zulherman, 2021). When used effectively, instructional media can help students grasp the material more clearly, making the learning process more efficient and generally improving understanding and performance. (Maielfi *et al*., 2023). Traditionally, instructional media were conventional and tangible. However, they have gradually transformed toward digital formats. This digitalization is closely associated with contemporary technological advancements, enabling instructional media to take the form of interactive multimedia—such as text, visual images, audio, video, and virtual reality—delivered through both hardware and software platforms. (Yuliawati *et al*., 2020).

Nevertheless, the utilization of digital media in environmental pollution learning remains suboptimal. Many teachers have not yet developed instructional media that truly fit their learning objectives, the needs of their students, the nature of the material, the available teaching time, as well as practical considerations such as accessibility and cost (Rahma, 2019). Media that are designed around students' needs can present learning content in a way that feels more meaningful and easier to understand, ultimately supporting more effective learning and deeper comprehension (Pradilasari *et al*., 2020). Hutchinson and Waters (1987) explain that needs analysis involves identifying learners' goals or competencies to be achieved, along with determining the strategies necessary to help them reach those goals (Hendriyani *et al*., 2018).

These conditions indicate a research gap, particularly the limited number of studies that specifically identify students' instructional media needs for environmental pollution topics from students' perspectives. Therefore, this study seeks to investigate students' needs, perceived barriers, and feedback in order to inform the development of future learning media that are more relevant, engaging, and supportive of enhancing students' environmental awareness.

METHOD

This study represents the needs assessment phase as the initial stage of a Research and Development (R&D) approach, aimed at identifying the needs of students, teachers, and existing learning conditions as the basis for developing instructional media. The research subjects

consisted of 62 eleventh-grade students from two classes and three biology teachers at SMA Negeri 1 Polokarto, selected using a cluster random sampling technique. The sample consisted of 62 eleventh-grade students and three biology teachers. This number was considered sufficient for a needs analysis study, which focuses on identifying learning problems and media requirements within a specific school context rather than generalizing findings broadly. The inclusion of teachers provided complementary perspectives, strengthening data validity. Cluster random sampling was implemented by randomly selecting one intact eleventh-grade class from the available classes, and all students in the selected class participated in the study. This approach maintained the natural classroom setting and ensured practical feasibility.

Data collection was conducted in August 2025 using a questionnaire distributed via Google Forms, which included Likert-scale items to measure respondents' perceptions and open-ended questions to obtain descriptive information regarding learning experiences and instructional media needs. The instrument underwent expert validation by a specialist in biology education. The needs analysis procedure included identifying the context of biology learning at the school, mapping the instructional content, and identifying both students' and teachers' needs related to instructional media. Data were analyzed using percentage analysis with the following formula:

$$\text{Percentage} = \frac{Obtained\ score}{Maximum\ score} \text{ x } 100\%$$

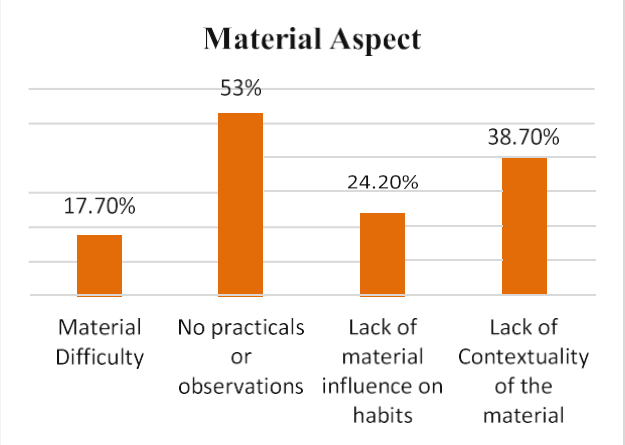
All collected information was factual and up-to-date, providing a strong foundation for the development of instructional media in subsequent stages.

RESULT AND DISCUSSION

A. Analysis of Students' Needs

An analysis of instructional media needs for learning about environmental pollution at SMA Negeri 1 Polokarto revealed various challenges faced by students and biology teachers. Female students predominantly completed the student questionnaire, compared with male students. The participating students were, on average, between 15 and 16 years old. The questionnaire consisted of 16 Likert-scale items. The visualization of students' data was categorized into two aspects: material and students' needs, as presented in Graphs 1 and 2.

Graph 1. Material Aspect



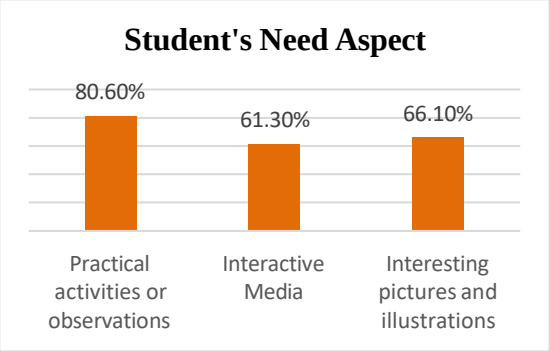
1. Material Aspect

Environmental pollution materials have a strong potential to be connected to students' surrounding environmental conditions. This is supported by findings on students' attitudes toward environmental care, their habits, and their thinking about pollution-related issues. Most students perceived that learning about environmental pollution fostered their environmental awareness. However, 24.20% of students reported that the learning had limited influence on their

behavior or their ability to propose solutions to environmental problems, and 38.70% stated that they did not receive real-world examples of pollution in their surroundings. Connecting learning content to real-life contexts enables students to build their own understanding. It strengthens their ability to transfer and apply their knowledge to new situations, especially in mathematics, science, and practical skills (Dewi & Primayana, 2019).

In general, students require context-based digital instructional media to learn about environmental pollution topics. Innovation in learning is needed not only to present content informatively but also to foster active student engagement. Learning materials related to environmental issues require students' active participation to be more effective. 53% of students reported the absence of practicum or observational activities on this topic, and 17.70% reported difficulties understandingthe material. Many studies have shown that active approaches—such as project-based learning, living laboratories, and participatory activities—can effectively increase student engagement, improve knowledge retention, and empower students to address environmental issues with greater awareness and responsibility toward the environment (Derevenskaia, 2014). Based on Demssie *et al*. (2023), learning approaches that are grounded in real-world environmental contexts help strengthen students' thinking skills and create opportunities for meaningful exchange of diverse ideas among them.

Graph 2. Student's Need Aspect



2. Student's Need Aspect

In the aspect of students' needs, the analysis results indicate that the majority of students (80.60%) expressed a preference for practicum or observational activities in the learning process. This finding suggests that students require direct, context-rich learning experiences that allow them to explore concepts actively. Activities such as practicums and observations not only strengthen conceptual understanding but also provide opportunities for students to develop scientific process skills that align with the objectives of 21st-century learning.

Furthermore, 61.30% of students reported a high level of interest in using interactive instructional media. This finding indicates that students expect learning media that can enhance engagement, provide feedback, and facilitate meaningful interaction during the learning process.

Furthermore, 66.70% of students expressed a preference for digital-based instructional media equipped with attractive visual elements, such as illustrations, animations, videos, and concise, easily understandable text. Mayer's Cognitive Theory of Multimedia Learning (2024) states that learning is more effective when information is presented through a combination of words and images, because individuals process information through

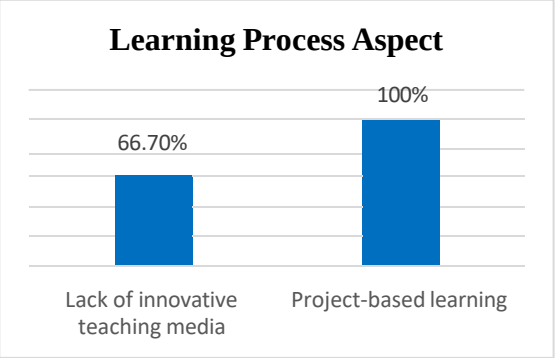
two separate cognitive channels—the visual–pictorial and the verbal–auditory. Each channel has a limited capacity; therefore, multimedia design should minimize extraneous cognitive load and support active learning processes by selecting, organizing, and integrating information effectively.

Students' preferences for digital instructional media indicate a shift in the learning characteristics of the current generation, who are becoming increasingly familiar with technology. Digital media are perceived as capable of providing more flexible and easily accessible content, both online and offline, thereby supporting both independent and structured learning processes. This development is consistent with global trends showing a decline in the use of conventional instructional media and a gradual shift toward the adoption of digital media in education (Ichsan *et al*., 2018)

B. Analysis of Teachers' Needs

The subsequent analysis was derived from responses provided by three biology teachers, as presented in Table 2. The questionnaire was completed by teachers with extensive teaching experience, averaging 25 years of service. The instrument consisted of 13 items, including Likert-scale questions and open-ended responses. The visualization of teachers' data was categorized into two aspects: the learning process and teachers' needs, as illustrated in Graphs 3 and 4.

Graph 3. Learning Process Aspect



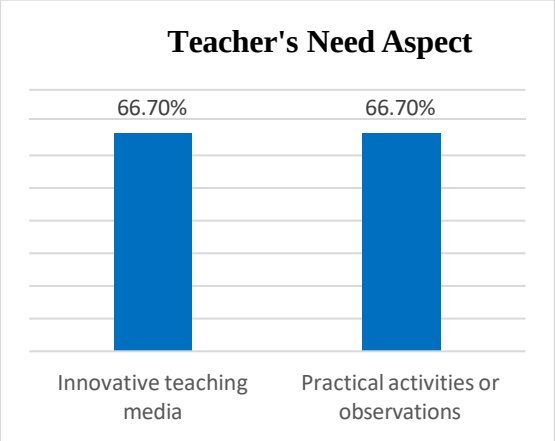
1. Learning Process Aspect

The survey results regarding the learning process indicate strong potential to transform instructional media from conventional formats, such as textbooks, into more innovative digital media. This finding is supported by data showing that 66.70% of teachers reported a lack of innovative instructional media, while all teachers (100%) expressed support for implementing project-based learning. This unanimous support reflects the need for learning media that not only deliver information but also facilitate higher-order thinking activities through exploration and problem-solving.

The digital transformation of instructional media is seen as a way to provide more personalized content that aligns with students' needs, while also offering varied and innovative ways to present learning materials (Safori *et al*., 2023). Audiovisual and digital-based learning media have also been shown to support diverse learning styles, enhance student engagement in the learning process, and foster collaboration and creativity during instructional activities (Nicolaou *et al*., 2019). These findings suggest that the development of digital instructional media on environmental pollution is not merely a response to technological advancement, but also an opportunity to enhance students'

interest in learning and deepen their understanding.

Graph 4. Teacher's Need Aspect



2. Teacher's Need Aspect

Teachers indicated that students' low interest in learning and their tendency to become bored when studying environmental pollution topics quickly are primarily due to the limited availability of innovative instructional media. This condition is reflected in the finding that 66.70% of teachers expressed a need for more innovative learning media. These data suggest that the instructional media currently in use have not facilitated active student engagement or effectively connected learning content with real-world environmental issues. In fact, active student involvement in learning can have a significant positive impact. Teachers who facilitate learning in a more participatory way can nurture students' sense of satisfaction and ownership over their learning, which in turn supports the development of lasting learning habits (Lee & Hannafin, 2016).

The development of digital media represents a potential solution to address these challenges. Digital media can be designed to support project-based learning by providing digital worksheets, interactive applications, or contextually developed instructional materials. The proposed digital media is designed to be accessible on all electronic devices, such as mobile phones, iPads, and laptops, and does not require high-end technological infrastructure. The interactive features promote active student engagement and enable teacher feedback, for example, through quizzes that provide immediate results and explanations. Contextual-based instructional media enable students to conduct direct observations and relate learning content to environmental phenomena in their surroundings. Survey results also indicate that 66.70% of teachers support the inclusion of practicum or observational activities, making digital media that facilitates such processes a relevant option. Contextual learning offers benefits for students across varying ability levels, as it allows learning contexts to be adapted to individual needs, thereby increasing learning satisfaction and reducing cognitive load (Rosa *et al*., 2022). Moreover, this approach fosters higher-order thinking skills, including analysis, synthesis, and evaluation, to address real-life problems, and engages students in inquiry-based activities that are crucial for developing critical and creative thinking skills (Toheri *et al*., 2020).

Based on the analysis of students' and teachers' needs, it is clear that there is an urgent need to develop innovative digital learning media. The instructional media to be developed should ideally integrate visual, audio, and interactive elements, functioning not only as learning aids but also as platforms for student participation in the construction of knowledge. Such cognitive development can be facilitated through various learning projects, such as practicum activities or environmental observations. In this context, a contextual learning approach plays a crucial role in

connecting learning content with students' real-life experiences. This approach is particularly relevant for environmental pollution topics, as students can use their immediate surroundings as an accessible object of study. For students, implementing a contextual approach not only fosters awareness of pollution issues in their environment but also develops critical thinking skills through in-depth analysis and solution-oriented problem-solving aimed at environmental sustainability.

CONCLUSION

The conclusions of this study indicate that learning environmental pollution topics continues to face various challenges, encompassing content-related aspects, the needs of both students and teachers, and the learning processes implemented in schools. Students require interactive digital media that not only present information in a visually engaging manner but also enable project-based activities that connect pollution concepts with real-world phenomena in their surrounding environment. Teachers likewise perceive that contextual digital media have the potential to enhance student engagement and conceptual understanding. These findings contribute theoretically by reinforcing the application of multimedia learning theory and contextual learning approaches in the development of science instructional media. From a practical perspective, the results underscore the need for digital media that can facilitate authentic learning experiences while simultaneously promoting students' critical thinking skills and environmental awareness. Based on these findings, future media development should focus on designing interactive platforms that integrate dynamic visuals, contextual learning pathways, and supporting tools for field observation or practicum activities, thereby addressing instructional needs more comprehensively. However, this study is limited by its small sample from a single school and by its reliance on descriptive analysis, which restricts generalizability and causal inference. Future research should involve larger samples and apply quasi-experimental or experimental designs to evaluate the effectiveness of the developed media in improving students' learning outcomes, critical thinking skills, and environmental attitudes.

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