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The Effect of PBL-STEAM Video-Assisted PBL-STEAM Using the Kampung Code Pollution Context

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Abstract

This study examines the effect of a video-assisted PBL-STEAM model using the Kampung Code pollution context on junior high school students' problem-solving ability and environmental care attitude. A quasi-experimental nonequivalent pretest–posttest control group design was employed. The sample consisted of two classes selected through cluster random sampling: one experimental class and one control class. Data were collected using a problem-solving test and an environmental care attitude questionnaire. Data analysis included normalized gain (N-Gain) and inferential statistics using an independent samples t-test and Mann–Whitney test. The results indicate that the experimental group achieved higher improvement in problem-solving ability (N-Gain = 0.35, medium) compared to the control group (N-Gain = 0.15, low), with a statistically significant difference ($p = 0.001$). In contrast, environmental care attitude showed low improvement in both groups (experimental = 0.14; control = 0.11), with no significant difference ($p = 0.569$). These findings suggest that video-assisted PBL-STEAM using a local environmental context is associated with improved cognitive outcomes, while affective outcomes may require longer and more sustained interventions.

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INTRODUCTION

Environmental pollution is one of the concepts of natural science, which requires a variety of scientific abilities, such as high-level thinking abilities, understanding of research, and problem-solving abilities. One of the abilities needed to understand environmental pollution is the ability to solve problems. Problem-solving abilities will help students learn to solve problems in the school environment and outside of school. However, environmental pollution is one of the fundamental topics in natural science that requires students to apply higher-order thinking skills and problem-solving abilities (Ardoin et al., 2020; Maharani et al., 2020; Sigit et al., 2017). This condition is consistent with the results of the Programme for International Student Assessment (PISA) 2018, which showed that Indonesia ranked 74th out of 79 participating countries, with an average score of 396 compared to the international average of 489 (OECD, 2019). These findings highlight the need for innovative instructional approaches that can foster higher-order thinking skills.

One way that can be used to increase problem-solving abilities is by using appropriate learning models and learning approaches according to the characteristics of the material being studied. Model Problem-Based Learning (PBL) is a learning model that really optimizes the issues of phenomena encountered in everyday life. PBL has been widely recognized as an effective instructional model to enhance students' problem-solving skills because it engages learners with authentic, real-world problems (Payung Allo et al., 2019;

Savery, 2015). Previous studies indicate that problem-based learning can significantly enhance students' higher-order thinking and problem-solving skills when implemented effectively (Yew & Goh, 2016; Dolmans et al., 2016). In addition, the integration of STEM or STEAM approaches has been shown to positively influence students' cognitive achievement and critical thinking skills (Amelia, 2019; Melati et al., 2019; Thibaut et al., 2018). The combination of PBL and STEAM is theoretically relevant because both approaches emphasize contextual learning, interdisciplinary integration, and real-life problem-solving.

Based on one important component of STEAM, namely technology, the rapid development of science and technology in the 21st century requires educators to integrate digital media into the learning process (Thibaut et al., 2018). The integration of technology in STEAM learning supports students in visualizing abstract concepts, analyzing real-world problems, and developing problem-solving skills (Kelley & Knowles, 2016). However, previous studies on PBL and STEAM implementation have predominantly focused on project activities and hands-on investigations, with limited integration of digital video media as a central instructional tool (Savery, 2015; Thibaut et al., 2018). Video-based learning offers several pedagogical advantages. According to Mayer (2019), multimedia learning through audio-visual representations can enhance students' cognitive processing by combining verbal and visual information, thereby improving conceptual understanding. Furthermore, educational videos can present authentic environmental issues in a contextual and realistic manner, which is essential in problem-based learning environments (Yew & Goh, 2016). Platforms such as YouTube allow teachers to present real environmental phenomena, making learning more meaningful and accessible, especially when integrating local potential into science learning. Despite these advantages, research indicates that many educators still underutilize technology to promote higher-order thinking and problem-solving skills (Rivalina, 2020). Therefore, integrating video media within the PBL-STEAM framework becomes a relevant innovation to optimize the technology component in STEAM while strengthening students' problem-solving abilities in environmental pollution topics.

Research shows that the Code River (Kali Code), located in the Special Region of Yogyakarta and flowing through several urban districts, including Yogyakarta City, represents a significant environmental feature of the region (Marlina, Brontowiyono, & Chasna, 2020). Water quality studies further indicate that the river's condition is substantially affected by anthropogenic activities and pollution, making it a relevant case of environmental degradation within an urban context (Fathrizky, 2022). As such, the Code River has strong potential to serve as a local environmental learning resource, particularly in environmental pollution material, where students can directly observe and analyze real-world issues. Integrating the local potential of the Code River and its surrounding tourism village context into environmental pollution learning can support students in identifying problems, proposing solutions, and evaluating possible actions related to environmental issues encountered in everyday life. Wilujeng (2017) suggests that the integration of local potential in science learning materials can enhance students' learning experiences and competencies. However, although local environmental contexts like the Code River possess rich contextual potential, their structured use as formal science learning resources remains limited in classroom practice. Many educators continue to rely on conventional textbook-based instruction and have not systematically incorporated local environmental phenomena into learning environments, which contributes to the gap between ideal learning implementation and actual practice (Shufa & Khusna, 2018). Therefore, there is a need to explore innovative instructional models that leverage local environmental resources to enhance students' problem-solving abilities and environmental care attitudes.

Based on an analysis of a clear gap between the ideal implementation of PBL-STEAM integrated with local environmental potential and the actual classroom practice. Although

PBL-STEAM is theoretically capable of enhancing students' problem-solving abilities and environmental care attitudes, its integration with local potential—particularly the Code River in Yogyakarta—through video-assisted learning has not been optimally implemented, with the aim of (1) analyzing the influence of the PBL-STEAM model assisted by the video media "Code Kampung Pollution" on the problem-solving abilities of junior high school students and (2) analyzing the influence of the PBL-STEAM model assisted by the video media "*Pencemaran Kampung Code"* towards environmental care attitudes of junior high school students.

METHODS

This study employed a quasi-experimental design with a nonequivalent pretest–posttest control group. The sample consisted of two classes selected using cluster random sampling, with class VII C as the experimental group and class VII D as the control group. The experimental and control groups consisted of 32 and 32 students, respectively. The intervention was conducted over X meetings. Both groups were taught by the same teacher to ensure consistency. The experimental group received video-assisted PBL-STEAM instruction using the Kampung Code pollution context, while the control group was taught using discovery-scientific learning supported by PowerPoint media.

Data were collected using a problem-solving test and an environmental care attitude questionnaire. The data were analyzed using N-Gain to measure improvement, an independent samples t-test for problem-solving ability, and a non-parametric Mann–Whitney test for environmental care attitude. Sampling was conducted using cluster random sampling. According to Creswell (2023), cluster random sampling is a probability sampling technique in which the researcher divides the population into naturally occurring groups (clusters) and then randomly selects entire clusters as the sample. This technique is particularly appropriate when the population is already organized into intact groups, such as classrooms, and when it is impractical to randomly select individuals from the entire population. In this study, intact classes were treated as clusters, and two classes were randomly selected to serve as the experimental and control groups. The design of this research is a nonequivalent pretest-posttest control group, which is illustrated in Table 1.

Table 1 Research design

Class	*Pretest*	Treatment	*Posttest*
Experiment	O_1	X	O_2
Control	O_3	Y	O_4

Information:

O_1 = Result of the pretest in the experimental class taught using the video media PBL-STEAM model.

O_2 = Result of the posttest in the experimental class taught using the video media PBL-STEAM model.

O_3 = Result of the pretest in the control class taught using the model discovery-scientific PPT media.

O_4 = Result of the posttest in the control class taught using the model discovery-scientific PPT media.

X = Treatment by applying the PBL-STEAM model assisted by video media

Y= Treatment by applying the model discovery scientifically by PPT

The data collection techniques in this study were intended to measure students' problem-solving abilities and environmental care attitudes. Two types of instruments were employed, namely test and non-test instruments. The test instrument consisted of 15 open-ended questions designed to assess students' problem-solving abilities. The items were developed based on the problem-solving ability indicators presented in Table 2.

Table 2 Grid of problem-solving abilities

No.	Indicator
1	Understanding the problem
2	Planning the solution
3	Implementing the solution according to the plan
4	Interpreting the results and reviewing the solution

The environmental care attitude instrument was validated through expert judgment to ensure content validity. However, empirical construct validity and reliability testing were not conducted in this study. The non-test instrument was a questionnaire used to measure students' environmental care attitudes. The questionnaire consisted of 20 items constructed using a four-point Likert scale (1 = strongly disagree to 4 = strongly agree). The items were developed based on the indicators of environmental care attitudes adapted from Irfianti et al. (2016), as presented in Table 3.

Table 3 Environmental care attitude questionnaire grid

Aspect	Indicator
Efforts to prevent damage to the surrounding natural environment	environmental care Reducing the use of plastic Waste management according to type Reduction of carbon Emissions energy savings
Efforts to improve existing natural damage happen	Tree planting Utilization of used goods

Instrument testing is carried out to determine the validity of test items, test reliability, and the level of difficulty of test items. Furthermore, the data from the instrument trial results were analyzed, and 13 of the 15 question instruments were obtained and found to be valid with a reliability of 0.809 (high category). Meanwhile, the environmental care attitude questionnaire only goes through an expert validation process. Data analysis techniques use prerequisite tests (normality and homogeneity), hypothesis testing (independent sample t-test and Mann-Whitney), and normalized gain.

RESULTS AND DISCUSSION

This study aims to analyze the effect of the PBL-STEAM model assisted by the video media "Pollution of Kampung Code" on junior high school students' problem-solving abilities and environmental care attitudes. Problem-solving ability in this study refers to students' capacity to identify environmental problems, analyze their causes, propose appropriate solutions, and evaluate alternative solutions critically. Meanwhile, an environmental care attitude reflects students' awareness, concern, and responsible behavior toward environmental issues in their surroundings.

Data on students' problem-solving abilities were obtained from initial ability scores (pretest) and final ability scores (posttest) through a problem-solving ability test administered before and after the implementation of the learning treatment in both the experimental and control classes. The comparison between pretest and posttest scores was used to determine the improvement in students' problem-solving performance following the intervention.

Similarly, data on environmental care attitudes were collected through a questionnaire administered before (pretest) and after (posttest) the treatment in both classes. The questionnaire measured changes in students' environmental awareness and attitudes after experiencing the PBL-STEAM learning process assisted by video media.

The results of students' problem-solving abilities and environmental care attitudes, including the initial and final scores, are presented in Table 4.

Table 4 Problem-solving ability and environment attitude scores

Value	Class	Test	Average	*N-Gain*
Problem-Solving Ability	Experiment	Pre	60	0.35
		Post	74	
	Control	Pre	59	0.15
		Post	65	
Environmental Attitude	Experiment	Pre	83	0.14
		Post	85	
	Control	Pre	81	0.11
		Post	84	

The N-Gain analysis showed that the experimental class obtained a mean N-Gain score of 0.35 in the medium category, while the control class obtained 0.15 in the low category. This indicates that the increase in problem-solving ability in the class taught using the PBL-STEAM model, assisted by the "Kampung Code Pollution" video, was higher than that of the class taught using conventional discovery-scientific learning.

Table 5 also shows that the experimental class obtained a pretest mean score of 83 and a posttest mean score of 85, resulting in an N-Gain of 0.14 (low category). The control class obtained pretest and posttest mean scores of 81 and 84, respectively, with an N-Gain of 0.11 (low category).

Hypothesis testing of students' problem-solving abilities uses data obtained from pretest-posttest problem-solving skills. Testing the research hypothesis to determine the effect of problem-solving abilities after receiving PBL-STEAM model learning assisted by the video media "Kampung Code Pollution." Based on the prerequisite tests, problem-solving ability data are normally distributed and have homogeneous variance, with recommendations for parametric statistical tests using the t-test. The hypothesis of the research will be accepted if the value of sig. (2-tailed) is < 0.05. The hypothesis test of the effect of treatment on students' problem-solving abilities is as follows:

H_0 = There is no influence of the PBL-STEAM model assisted by video media "Kampung Code Pollution" on students' problem-solving abilities

H_a = There is an influence on the PBL-STEAM model assisted by the video media "Kampung Code Pollution" on students' problem-solving abilities

As for the test results, the independent sample t-test of students' problem-solving abilities is presented in Table 5.

Table 5 Independent sample t-test of problem-solving skill

Sig. (2-tailed)	Information
0.001	H_0 Rejected

The medium improvement in the experimental class can be explained by the characteristics of the PBL-STEAM model. Problem-based learning encourages students to identify problems, formulate hypotheses, design solution strategies, and evaluate results through structured inquiry. This aligns with constructivist learning theory, which emphasizes active knowledge construction through authentic problem situations.

The integration of STEAM further strengthens this process by promoting interdisciplinary thinking and engineering design practices. Students are not only required to understand the environmental pollution conceptually but also to analyze real cases and propose contextual solutions. The use of video media presenting the real condition of Kampung Code provided a concrete visualization of pollution problems, which likely enhanced students' cognitive engagement and facilitated meaningful learning.

Indicator-level analysis in the thesis also showed that the highest N-Gain in the experimental class was in identifying problems (0.67, medium), while planning solutions was relatively lower (0.28, low). This suggests that students were able to recognize environmental issues effectively but still needed stronger prior knowledge to design structured solution strategies. Previous research (Yuwono et al., 2018) explains that the planning stage requires sufficient prior conceptual understanding to select appropriate strategies, which may explain why this indicator did not reach a higher category.

In contrast, the control class showed the lowest improvement in identifying problems (0.02, low), indicating that conventional instruction provided fewer opportunities for students to practice analytical problem identification. This difference supports previous findings that PBL-based learning significantly improves problem-solving skills because students actively engage in problem analysis and solution development (Djuandi, 2016; Melati et al., 2019).

The higher improvement in problem-solving ability observed in the experimental group may be explained by the characteristics of the PBL-STEAM approach. Problem-based learning engages students in analyzing authentic problems, constructing solutions, and evaluating outcomes through inquiry-based processes. The integration of STEAM further supports interdisciplinary thinking and application of knowledge in real-world contexts. The use of video media representing Kampung Code pollution likely enhanced students' understanding by providing concrete and contextualized environmental issues. These findings are consistent with previous studies indicating that PBL-based instruction can enhance students' problem-solving and higher-order thinking skills (Djuandi, 2016; Melati et al., 2019).

Overall, the statistical and N-Gain results consistently indicate that the PBL-STEAM model assisted by contextual video media is effective in improving students' cognitive competencies, particularly structured problem-solving skills. Hypothesis testing of students' environmental care attitudes uses data obtained from the initial and final environmental care attitude questionnaires. Testing the research hypothesis to determine the effect of environmental care attitudes after receiving PBL-STEAM model learning assisted by the video media "Kampung Code Pollution." Based on the prerequisite test, the environmental care attitude data is not normally distributed and has a homogeneous variance, with the recommendation of using the parametric statistical test Mann-Whitney U.

The N-Gain analysis for environmental care attitude showed that the experimental class obtained 0.14 and the control class obtained 0.11, both categorized as low. Although there was a slight increase in both classes, the improvement was minimal.

The hypothesis of the research will be accepted if the value of the significance. (2-tailed) < 0.05 then H_0 rejected, and H_a accepted. The hypothesis test of the effect of treatment on students' environmentally caring attitude is as follows:

H_0 = There is no influence on the PBL-STEAM model assisted by video media "Code Village Pollution" towards students' environmental care attitudes

H_a = There is an influence on the PBL-STEAM model assisted by the video media "Kampung Code Pollution" on students' environmental care attitudes

As for the test results, students' environmental care attitudes are presented in Table 6.

Table 6 Mann-Whitney test of environmentally caring attitude

Sig. (2-tailed)	**Information**
0.569	H_0 accepted

Hypothesis testing on environmental care attitudes uses Mann-Whitney because the data are not normally distributed. The reason the data is not normally distributed is that there is a significant difference in the final score between the data in one class, causing outliers. The existence of outliers can cause abnormal data distribution, bias in parameter estimates, and influence the significance results of parameter testing (Barus & Sutarman, 2023). The experimental group showed a higher increase in problem-solving ability compared to the control group, as indicated by the N-gain scores (0.35 vs 0.15). An independent samples t-test revealed a statistically significant difference between the two groups ($p = 0.001$).

For environmental care attitude, both groups demonstrated low improvement (0.14 in the experimental group and 0.11 in the control group). The Mann–Whitney test indicated no significant difference between groups ($p = 0.569$). There has been an increase in the PBL-STEAM model assisted by the YouTube video media "Code River Pollution" because the STEAM approach with the PBL model is very suitable when integrated; both have the characteristic of using real problems as a basis for learning. Approaches that are appropriate to the PBL learning model include Science, Technology, Engineering, Art, and Mathematics (STEAM) (Amelia, 2019). In this research, researchers use real problems by integrating local potential so that students are able to solve problems with good solutions. Rezania et al. (2023) stated that the main goal of PBL is to promote problem-solving, critical thinking, collaboration, and students' communication skills. In this way, students will be able to develop a deeper understanding of the concepts studied, as well as gain the skills needed to face real-world situations. So the model, approach, media, and local potential used in this research facilitate students' influence on the improvement of problem-solving abilities.

Even though there is a good increase in problem-solving abilities, this does not have an effect on students' environmental care attitudes. The results of hypothesis testing in this study did not show significant differences in environmental care attitudes; these results are quite different from the results of several previous studies. Djuandi (2016) explained that there were differences in students' attitudes towards the environment before and after treatment with the problem-based learning model. However, if we look at the numerical data, the values of N-Gain, there is a difference in attitudes towards environmental care between the experimental class and the control class, but not much of one.

Based on the data on the average value of problem-solving ability, the average value of each indicator of problem-solving ability can be further explained. As for average N-Gain, each indicator of the problem-solving ability of the experimental and control classes can be seen in Figure 1.

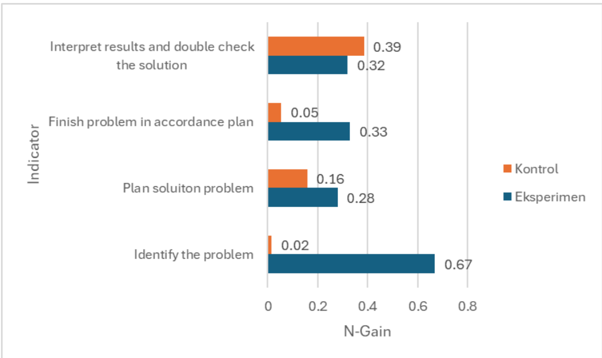

Figure 1 Comparison of N-Gain PSA indicators

Figure 1 shows that of the four existing indicators of problem-solving ability, the average N-Gain is the lowest for the experimental class, the planning completion indicator, which was 0.28 in the 'low' category. The low aspect of planning solutions in the experimental class is because students do not yet know the general knowledge to solve the problems they face, or have never faced these problems before. This is supported by previous research from Yuwono et al. (2018) stating that, at the step of preparing a plan to solve a problem, prior knowledge is needed to apply strategies that make it easier to solve the problems given.

The highest indicator of problem-solving ability in the experimental class is identifying problems with values N-Gain 0.67, 'medium' category. Yuwono et al. (2018) explain that in the problem identification stage, students are said to have reached this stage if they know or understand the problem being asked in the question correctly. In contrast to the experimental class, the highest indicator of problem-solving ability in the control class is interpreting the results and checking the solution again, with a value of N-Gain 0.39 in the 'medium' category. The N-Gain value of this indicator is higher in the experimental class because most of the control class students have personal experience in dealing with environmental pollution around where they live.

Based on the data on the average value of environmental caring attitude in Table 5, the average value of each indicator of environmental caring attitude can be further explained. As for average N-Gain, each indicator of the environmental care attitude of the experimental and control classes can be seen in Figure 2.

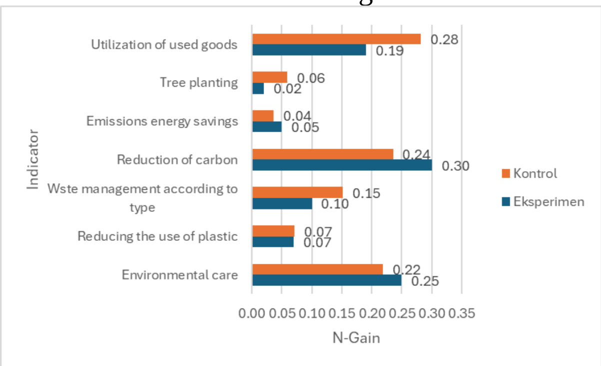

Figure 2 Comparison N-Gain ECA indicator

Figure 2 shows that of the seven environmental care attitude indicators, the lowest average N-Gain of the environmental care attitude indicator for the experimental class is tree planting with an N-Gain value of 0.02 in the 'low' category, whereas the lowest N-Gain indicator of environmental care from the control class is energy saving with an N-Gain value of 0.04 in the 'low' category. The low level of environmental care in terms of tree planting and energy-saving indicators is due to the fact that they have never had practical experience in tree planting, and energy-saving practices were applied when this research took place because the teacher gave a real example of wasting energy, namely, still turning on the classroom lights, which were already bright enough from the beam of sunlight.

The highest average N-Gain on the highest environmental care attitude indicator in the experimental class is a reduction in carbon emissions of 0.30 in the 'medium' category. The awareness of most of the experimental class students not to burn rubbish, reduce the use of private vehicles, and transport themselves to school using bicycles and public transportation is an attitude of caring for the environment that has been formed within themselves. While providing the material, the teacher also provides reinforcement of good attitudes and actions to protect the environment from environmental pollution. Forming attitudes in individuals apart from self-awareness also requires encouragement from external factors, such as teachers.

In contrast, no significant difference was found in environmental care attitude between the experimental and control groups. This finding should be interpreted cautiously. One possible explanation is that environmental attitudes represent affective constructs that tend to develop over a longer period and are influenced by multiple contexts beyond classroom instruction. Therefore, short-term interventions may not be sufficient to produce measurable changes.

Additionally, the use of self-report questionnaires may limit the accuracy of capturing actual behavioral change. As such, the absence of significant findings does not necessarily indicate the ineffectiveness of the intervention, but rather reflects the complexity of measuring affective outcomes. This interpretation aligns with previous research suggesting that environmental attitudes require sustained reinforcement and experiential engagement (Lestari, 2018). Additionally, environmental care attitudes in this study were measured using self-report questionnaires. Such instruments may not fully capture actual behavioral change and may be influenced by social desirability bias. The limited duration of the intervention may also have contributed to the minimal improvement observed. Although statistical testing showed no significant difference, the experimental class demonstrated slightly higher N-Gain values than the control class. This suggests that while the intervention may have initiated awareness, the magnitude of change was insufficient to produce significant differences within the research timeframe. These findings indicate that improving environmental care attitudes likely requires longer implementation periods, experiential learning activities, and integration with school-wide environmental programs.

CONCLUSION

This study indicates that video-assisted PBL-STEAM using the Kampung Code pollution context was associated with higher improvement in students' problem-solving ability compared to conventional instruction. However, no significant difference was observed in environmental care attitude between groups. These findings suggest that while the intervention supports cognitive development, affective outcomes may require longer-term and more comprehensive approaches. This is evidenced by the N-Gain score in the medium category and the independent sample t-test result ($0.001 < 0.05$), indicating that the hypothesis was accepted. However, the model does not significantly influence students' environmental care attitudes. This is indicated by the low N-Gain score and the Mann–Whitney test result ($0.569 > 0.05$), meaning that the hypothesis was not supported. These findings suggest that while the PBL-STEAM model is effective in improving cognitive competencies, changes in affective aspects require longer implementation and additional reinforcement strategies.

This study indicates that video-assisted PBL-STEAM using the Kampung Code pollution context is associated with higher improvement in students' problem-solving ability compared to conventional instruction. However, no significant difference was observed in environmental care attitude between groups. These findings have several implications. Practically, teachers are encouraged to integrate PBL-STEAM with contextual video media to support students' problem-solving skills, particularly by presenting real-world environmental issues that are relevant to students' daily lives. In terms of curriculum development, the integration of interdisciplinary approaches such as STEAM with local environmental contexts can be considered to strengthen meaningful learning and promote higher-order thinking skills.

However, the limited impact on environmental care attitudes suggests that affective outcomes require more sustained and long-term interventions beyond short classroom implementation. Therefore, future research is recommended to explore longer intervention durations, incorporate experiential learning activities, and utilize more comprehensive assessment methods to better capture changes in students' environmental attitudes.

This study has several limitations. First, the environmental care attitude instrument was limited to a questionnaire without observational data, which may not fully capture students' actual behavior. Second, the research was limited to environmental pollution material. Future studies are recommended to include observational instruments to strengthen attitude measurement and explore other science materials integrated with the local potential of the Code River.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, KKR and IW; methodology, KKR and IW; formal analysis, KKR; investigation, KKR; resources, IW; writing—original draft preparation, KKR; writing—review and editing, IW; supervision, IW, and others.

AI DISCLOSURE STATEMENT

The author used ChatGPT during the preparation of this work for language improvement and drafting assistance. After using the tool/service, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the content of the publication. The authors declare that this research was prepared, researched, written, and edited without the aid of artificial intelligence (AI) techniques.

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