



Decision-making-oriented cooperative learning in environmental education: a quasi-experimental study on students' scientific attitudes

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Abstract

Purpose: This study aims to investigate the effectiveness of decision-making-oriented cooperative learning in enhancing students' scientific attitudes in environmental change education.

Method: A quasi-experimental design with a non-equivalent control group was employed. The study involved two groups of tenth-grade students from a senior high school, consisting of an experimental group taught using decision-making-oriented cooperative learning and a control group taught using an inquiry-based approach. Data were collected through a validated scientific attitude questionnaire and observation sheets. Statistical analysis was conducted using an independent sample t-test at a significance level of 0.05.

Findings: The results revealed that students in the experimental group demonstrated significantly higher scientific attitude scores compared to those in the control group ($t = 3.637$, $p < 0.05$). The integration of decision-making processes in cooperative learning effectively promoted active engagement, critical evaluation of information, and responsible attitudes toward environmental issues.

Significance: This study contributes to the growing body of research on decision-making in education by providing empirical evidence that decision-making-oriented cooperative learning is a promising pedagogical approach for fostering scientific attitudes. The findings offer practical implications for educators in designing student-centered learning environments that integrate decision-making skills within environmental education contexts.

INTRODUCTION

Scientific attitudes play a crucial role in shaping students' ability to think critically, evaluate evidence, and respond to scientific problems in meaningful ways. These attitudes include curiosity, openness to new ideas, respect for empirical evidence, and a sense of responsibility toward the environment. In the context of environmental change, students are required not only to understand scientific concepts but also to interpret complex issues and make informed decisions (Dawson & Carson, 2020; Kurup et al., 2021; Osborne & Pimentel, 2023; Rousell & Cutter-Mackenzie-Knowles, 2020). Therefore, the development of scientific attitudes is essential for preparing students to address real-world environmental challenges. However, educational practices often prioritize cognitive achievement while giving less attention to affective outcomes such as attitudes and values. This imbalance can limit students' ability to apply scientific knowledge in practical and socially responsible contexts (Gerrits et al., 2022). As a result, students may lack the motivation and awareness needed to engage with environmental issues critically. In addition, the ability to make decisions based on scientific reasoning is closely linked to the development of these attitudes. Without strong scientific attitudes, students may struggle to evaluate information and respond appropriately to emerging challenges (Barzilai & Chinn, 2020; DeCoito & Estaiteyeh, 2022; Owens et al., 2020; Sasway & Kelly, 2021). This

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situation highlights the need for instructional approaches that integrate both cognitive and affective dimensions of learning. Therefore, strengthening scientific attitudes should become a central goal in science education.

Despite this need, many classroom practices still rely on teacher-centered approaches that emphasize content delivery rather than active student engagement. Such approaches tend to limit opportunities for students to explore ideas, ask questions, and develop independent thinking skills. Consequently, students may exhibit low levels of curiosity, limited engagement in learning activities, and a lack of responsibility toward environmental issues (H.-Y. T. Lee Silvia Wen-Yu, 2024; S. W.-Y. Lee et al., 2022; Yusuf & Fajri, 2022). In many cases, students are not actively involved in problem-solving processes, which reduces their ability to connect scientific knowledge with real-life situations (Akben, 2020; Aslan & Duruhan, 2021; Tan et al., 2023; Topsakal et al., 2022). This condition reflects a gap between instructional practices and the goals of science education. To address this issue, more interactive and student-centered learning strategies are required. Cooperative learning has been widely recognized as an effective approach to promote collaboration, communication, and active participation among students (Ngoc Tuong Nguyen & Thi Kim Oanh, 2025; Silva et al., 2021; Yang, 2023; Zhou & Colomer, 2024). Through group interactions, students can exchange ideas, build shared understanding, and support each other's learning. However, cooperative learning is often implemented without structured mechanisms that guide students in making decisions. As a result, its potential to develop higher-order thinking and scientific attitudes is not fully realized. This limitation suggests that cooperative learning needs to be enhanced with additional components that promote deeper cognitive engagement. Therefore, integrating decision-making processes into cooperative learning may offer a more effective instructional approach.

Decision-making is an essential skill in science education, particularly in dealing with complex and uncertain problems related to environmental change. It involves analyzing information, considering alternative solutions, and selecting the most appropriate course of action based on evidence and reasoning. In educational contexts, decision-making can help students develop critical thinking, problem-solving abilities, and responsible attitudes (Ahmady & Shahbazi, 2020; Chang et al., 2020; Khazen et al., 2025; Kyambade et al., 2025). However, decision-making is often treated as a separate skill rather than being integrated into classroom learning activities. This separation limits students' opportunities to apply decision-making in meaningful learning situations. Moreover, existing instructional practices tend to emphasize knowledge acquisition rather than the development of decision-making competencies (Abedi, 2024; Cherukunnath & Singh, 2022; Gesel et al., 2021). As a result, students may have difficulty applying scientific knowledge when faced with real-world problems. In environmental education, this limitation becomes more evident because students are expected to make responsible decisions that affect both society and the environment (Edsand & Broich, 2020; Kopnina, 2020; Reid et al., 2021). Therefore, there is a need to design learning approaches that combine decision-making processes with collaborative learning activities. Such integration can encourage students to engage actively in discussions, evaluate evidence collectively, and reach informed

conclusions. However, empirical evidence supporting this integrated approach remains limited.

This gap highlights the importance of further investigation into decision-making-oriented cooperative learning in science education. Despite the growing body of research in science education, current studies predominantly emphasize the effectiveness of cooperative learning in improving students' engagement and cognitive outcomes, particularly in inquiry-based and collaborative contexts (Gillies, 2023; Møgelvang & Nylén, 2023), while other works highlight the increasing importance of decision-making skills in addressing complex scientific and societal issues, especially within socio-scientific and STEM-based learning environments (Osborne & Pimentel, 2023; Schenk et al., 2021; Wahono et al., 2021). Furthermore, several studies have explored the role of argumentation and scientific reasoning in supporting informed decision-making in science education (Allchin & Zemplén, 2020), as well as the integration of innovative approaches such as machine learning and assessment strategies to enhance decision-making processes (Zhai, 2021). However, these studies largely focus on cognitive domains, such as critical thinking, scientific literacy, and academic achievement (Dewi et al., 2021; Mao et al., 2021), with relatively limited attention given to affective outcomes, particularly students' scientific attitudes. In addition, although cooperative learning and decision-making have been widely investigated as separate constructs, there remains a lack of empirical research that explicitly integrates decision-making-oriented approaches within cooperative learning frameworks to examine their combined effect on scientific attitudes, especially in the context of environmental change education, which requires both critical evaluation and responsible decision-making. Therefore, this gap highlights the need for further investigation into how decision-making-based cooperative learning can contribute to the development of students' scientific attitudes in environmentally relevant learning contexts.

Based on the identified issues, this study aims to examine the effectiveness of decision-making-oriented cooperative learning in enhancing students' scientific attitudes in environmental change education. The study focuses on how structured decision-making processes within cooperative learning activities can influence students' curiosity, respect for evidence, and environmental awareness. By applying a quasi-experimental design, this research compares the outcomes between students who experience decision-making-oriented learning and those who receive conventional instruction. The study also seeks to provide a deeper understanding of how instructional strategies can support both cognitive and affective development. In addition, this research aims to contribute to the improvement of science education practices by offering an alternative approach that integrates collaboration and decision-making. The findings are expected to demonstrate the potential of this approach in fostering more meaningful learning experiences. Furthermore, this study highlights the importance of aligning classroom practices with real-world problem-solving demands. This is particularly relevant in environmental education, where students are required to evaluate issues and make responsible decisions. The results of this research may provide practical guidance for educators in designing more effective learning environments. Ultimately, this study seeks to support the

development of students who are not only knowledgeable but also capable of making informed and responsible decisions in complex situations.

LITERATURE REVIEW

Scientific attitudes represent a key dimension in science education that extends beyond the acquisition of factual knowledge. These attitudes reflect how learners approach scientific inquiry, interpret evidence, and respond to complex problems. They are generally characterized by curiosity, openness to new ideas, critical thinking, and a willingness to evaluate information objectively (Hendekci, 2025; Manassero-Mas et al., 2022; Silvia & Christensen, 2020). In educational contexts, scientific attitudes are considered essential for fostering responsible and reflective learners (Colomer et al., 2020; Zhou et al., 2025). The development of these attitudes is closely linked to students' ability to engage actively in learning processes rather than passively receiving information (Díez-Palomar et al., 2020; Howell, 2021; Rezai et al., 2025). When students demonstrate strong scientific attitudes, they tend to show higher levels of engagement and deeper understanding of scientific concepts. Moreover, scientific attitudes support the application of knowledge in real-life situations, particularly in addressing environmental issues. However, the cultivation of these attitudes requires intentional instructional design. Traditional teaching approaches that emphasize memorization may not provide sufficient opportunities for students to develop these competencies [need citation]. Therefore, innovative learning strategies are necessary to promote both cognitive and affective development in science education.

Cooperative learning has been widely recognized as an effective instructional approach that encourages active participation and collaboration among students. This approach is based on the principle that learning occurs more effectively when students work together to achieve shared goals. Through cooperative learning, students are able to exchange ideas, discuss concepts, and construct knowledge collectively (Bassachs et al., 2020; Bouton et al., 2021; Koszalka et al., 2021; Yang, 2023). The social interaction involved in this process also contributes to the development of communication skills and mutual respect (Kiptiah, 2023). In addition, cooperative learning provides opportunities for students to take responsibility for their own learning and the learning of others (Bjørke & Mordal Moen, 2020; Mendo-Lázaro et al., 2022). This shared responsibility can enhance motivation and engagement in classroom activities. Furthermore, cooperative learning has been shown to support the development of higher-order thinking skills. However, the effectiveness of this approach depends on how it is implemented in the classroom. Without clear structure and guidance, group activities may become unproductive or dominated by certain individuals. This limitation highlights the importance of integrating structured processes within cooperative learning. Therefore, enhancing cooperative learning with additional components such as decision-making processes may increase its effectiveness.

Decision-making is an essential competency in science education, particularly in contexts that involve complex and uncertain issues. It requires students to analyze information, consider multiple perspectives, and select appropriate solutions based on evidence (Kastrati et al., 2021; Kumah et al., 2022). In learning environments, decision-making can be used as a tool to promote critical thinking and problem-solving skills

(Ahmady & Shahbazi, 2020; Chang et al., 2020; Song & Cai, 2024). This process encourages students to evaluate alternatives and justify their choices logically. In addition, decision-making helps students develop a sense of responsibility for the consequences of their actions. In the context of environmental education, decision-making is particularly relevant because students are often faced with real-world problems that require thoughtful and informed responses (David, 2025; Feijoo-Garcia et al., 2024; Hadjimichael et al., 2024). However, decision-making is often treated as a separate skill rather than being integrated into classroom learning activities. As a result, students may not have sufficient opportunities to practice decision-making in meaningful contexts. Integrating decision-making into learning activities can provide students with practical experience in applying scientific knowledge. This integration also supports the development of both cognitive and affective competencies. Therefore, incorporating decision-making into cooperative learning may create a more comprehensive learning experience.

Environmental change education provides a relevant context for developing both scientific understanding and responsible attitudes. This field addresses issues such as climate change, pollution, and resource management, which require informed decision-making and critical evaluation (Davamani et al., 2024; Miller et al., 2023; Motlaghzadeh et al., 2023; Ncube & Ngulube, 2024). In such contexts, students must not only understand scientific concepts but also consider the social and ethical implications of their decisions. This makes environmental education an ideal setting for applying decision-making-oriented learning approaches. Through this approach, students can engage in discussions, analyze real-world problems, and propose solutions collaboratively. In addition, environmental education encourages students to develop a sense of responsibility toward the natural world. This sense of responsibility is closely related to the development of scientific attitudes. However, many existing teaching practices in environmental education still focus primarily on knowledge transmission. This limits students' ability to develop the skills needed to address complex environmental challenges. Therefore, there is a need for instructional approaches that integrate knowledge, skills, and attitudes. Decision-making-oriented cooperative learning offers a promising framework for achieving this integration.

Despite the recognized importance of cooperative learning and decision-making in science education, there is still a lack of research that combines these approaches to examine their impact on scientific attitudes. Most studies tend to focus on cognitive outcomes such as academic achievement and critical thinking. While these outcomes are important, they do not fully capture the affective dimension of learning. In particular, scientific attitudes remain underexplored in relation to decision-making-based instructional strategies. Furthermore, research that integrates decision-making within cooperative learning frameworks is still limited. This gap is especially evident in the context of environmental change education, where both decision-making and scientific attitudes are highly relevant. As a result, there is a need for empirical studies that examine how these approaches can be combined effectively. Understanding this relationship can provide valuable insights for improving instructional practices. It can also contribute to the development of more holistic learning models that address both cognitive and affective domains. Therefore, this study seeks to address this gap by investigating the role of decision-making-oriented cooperative learning in enhancing students' scientific attitudes.

This approach is expected to provide a more comprehensive understanding of effective science education strategies.

METHOD

Research Design

This study employed a quasi-experimental design using a non-equivalent control group structure to examine the effectiveness of decision-making-oriented cooperative learning on students' scientific attitudes. The design involved two groups: an experimental group that received instruction through decision-making-oriented cooperative learning and a control group that was taught using a conventional inquiry-based approach. Both groups were assessed using pretest and posttest measures to identify changes in students' scientific attitudes. The use of a quasi-experimental design was considered appropriate because the participants were drawn from existing classroom settings without random assignment at the individual level. This design allowed for a comparison of learning outcomes between groups under real classroom conditions. The independent variable in this study was the instructional model applied in the classroom, while the dependent variable was students' scientific attitudes. To ensure internal validity, both groups were taught the same subject matter within the same time frame. The learning materials, duration, and assessment procedures were standardized across groups. The experimental treatment focused on integrating structured decision-making processes within cooperative learning activities. This approach was designed to encourage students to analyze problems, evaluate alternatives, and make evidence-based decisions collaboratively.

Participants

The participants in this study were tenth-grade students from a public senior high school. Two intact classes were selected as the research sample, consisting of one experimental group and one control group. Each group included approximately equal numbers of students to ensure comparability. The selection of participants was conducted using a cluster sampling technique based on existing classroom groupings. This approach was chosen to maintain the natural learning environment and avoid disruption to the school schedule. The students in both groups had relatively similar academic backgrounds and had previously studied basic science concepts. No significant differences in prior knowledge were assumed between the two groups at the beginning of the study. The participants were considered appropriate for this research because they were at a developmental stage where scientific attitudes and decision-making skills can be effectively cultivated. In addition, the environmental change topic was relevant to their curriculum, making the learning experience meaningful and contextual. The participation of students was conducted with consideration of ethical principles, ensuring that all participants were treated fairly and respectfully. Both groups were given equal opportunities to engage in the learning process.

Instruments

Data in this study were collected using a scientific attitude questionnaire and observation sheets designed to assess students' attitudes during the learning process. The questionnaire was developed based on key dimensions of scientific attitudes, including

curiosity, respect for evidence, flexibility in thinking, and environmental awareness. Each item was structured using a Likert scale to measure the degree of students' agreement with specific statements. The observation sheet was used to record students' behavior and participation during classroom activities. This instrument allowed for a more comprehensive assessment by capturing real-time interactions and responses. Before implementation, the instruments were reviewed to ensure clarity and relevance to the research objectives. The data collection process was conducted in two stages: pretest and posttest. The pretest was administered before the intervention to determine students' initial scientific attitudes. The posttest was conducted after the instructional treatment to measure changes in students' attitudes. In addition to questionnaire data, observational data were collected throughout the learning sessions. This combination of instruments provided both quantitative and qualitative insights into students' scientific attitudes.

Data Analysis

The data obtained from the questionnaire were analyzed using statistical methods to determine the effectiveness of the instructional approach. Descriptive statistics were first used to summarize the data, including mean scores and standard deviations. Inferential analysis was then conducted to compare the results between the experimental and control groups. An independent sample t-test was used to examine whether there were significant differences in students' scientific attitudes between the two groups. The level of significance was set at 0.05 to determine statistical significance. Prior to hypothesis testing, assumptions such as normality and homogeneity of variance were considered. The analysis focused on identifying differences in posttest scores as well as changes from pretest to posttest. In addition, observational data were analyzed to support and interpret the quantitative findings. The results of the analysis were used to evaluate the impact of decision-making-oriented cooperative learning on students' scientific attitudes. This approach allowed for a comprehensive understanding of both statistical outcomes and classroom dynamics.

Procedure

The research procedure was conducted in several stages to ensure systematic implementation of the study. The first stage involved preparation, including the development of lesson plans, instruments, and research design. In the second stage, the pretest was administered to both the experimental and control groups to measure initial scientific attitudes. The third stage involved the implementation of the instructional treatment. In the experimental group, students participated in cooperative learning activities that incorporated structured decision-making processes, such as identifying problems, analyzing alternatives, and selecting solutions collaboratively. In contrast, the control group received instruction using a conventional approach that focused on inquiry-based learning without explicit decision-making components. The treatment was conducted over several learning sessions covering environmental change topics. During the implementation, observations were carried out to monitor students' engagement and behavior. After the completion of the treatment, the posttest was administered to both groups. The final stage involved data analysis and interpretation of results. This procedure

ensured that the study was conducted in a structured and controlled manner, allowing for valid and reliable findings.

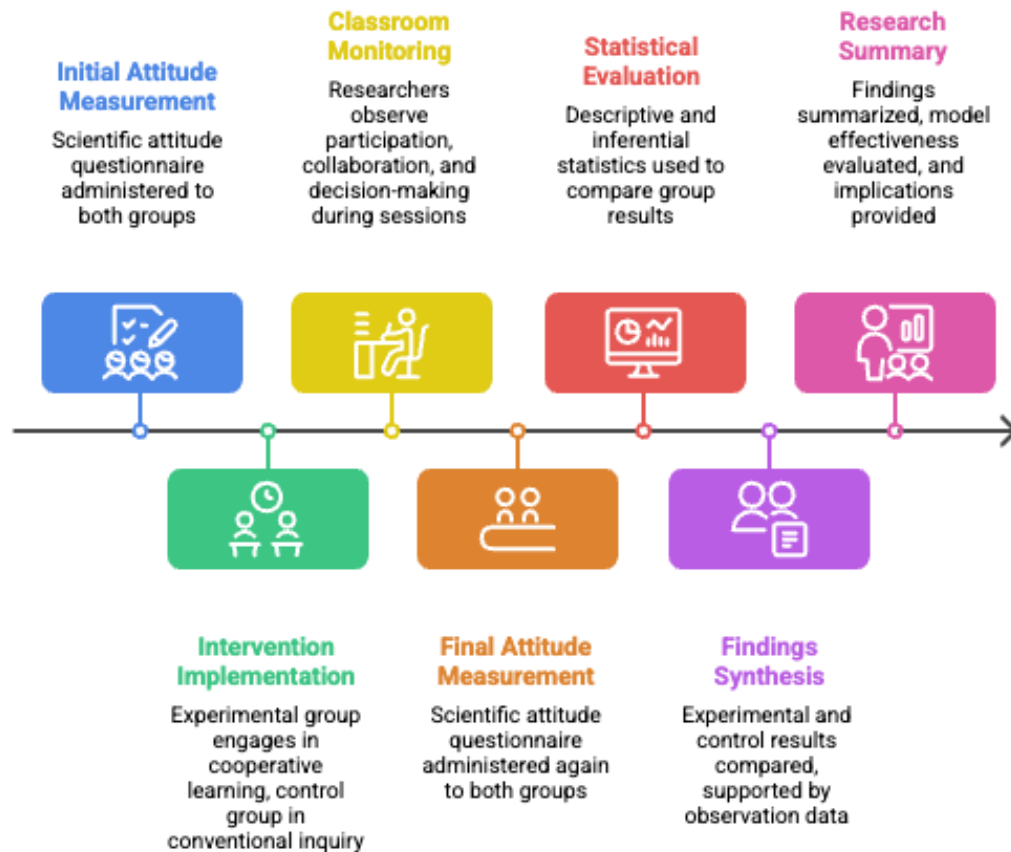


Figure 1. Research Procedure Flowchart

RESULTS AND DISCUSSION

Result

This section presents the empirical findings of the study, focusing on the effect of decision-making-oriented cooperative learning on students' scientific attitudes. The results are organized into four main components: descriptive statistics, assumption testing, inferential analysis, and observational findings. The presentation is supported by tables and graphical representations to enhance clarity and interpretability.

Descriptive Analysis of Scientific Attitudes

Descriptive statistics were calculated to examine the distribution of students' scientific attitude scores in both experimental and control groups. The analysis included mean scores and standard deviations for both pretest and posttest.

Table 1. Descriptive statistics of scientific attitude score

Group	Test	Mean (M)	Std. Deviation (SD)
Experimental Group	Pretest	65.20	6.45
Experimental Group	Posttest	82.75	5.80
Control Group	Pretest	64.85	6.70
Control Group	Posttest	74.10	6.25

The results indicate that both groups started with relatively similar pretest scores, suggesting comparable baseline conditions. However, the posttest scores reveal a more

substantial increase in the experimental group compared to the control group. The reduction in standard deviation in the experimental group also suggests more consistent improvements among students.

Assumption Testing

Before conducting inferential analysis, data assumptions were examined to ensure the validity of statistical testing.

Table 2. Normality and homogeneity tests

Test Type	Group	Sig. Value	Interpretation
Normality	Experimental	0.200	Normal Distribution
Normality	Control	0.175	Normal Distribution
Homogeneity Test	Both Groups	0.312	Homogeneous

The results show that all significance values exceeded 0.05, indicating that the data were normally distributed and homogeneous. Therefore, the use of parametric tests was appropriate for further analysis.

Inferential Analysis

To examine the effect of the intervention, an independent sample t-test was conducted on posttest scores.

Table 3. Independent Sample t-test results

Variable	Mean Difference	t-value	Sig. (p)	Decision
Scientific Attitudes	8.65	3.637	0.001	Significant

The statistical results indicate that the p-value (0.001) is lower than the significance threshold of 0.05. This confirms that there is a statistically significant difference between the experimental and control groups. The positive mean difference indicates that the experimental group outperformed the control group in terms of scientific attitudes.

Gain Score Analysis

To evaluate the magnitude of improvement, normalized gain scores were calculated.

Table 4. Normalized Gain Score

Group	N-Gain	Category
Experimental Group	0.50	Moderate
Control Group	0.26	Low

The experimental group achieved a moderate gain, indicating a meaningful improvement in scientific attitudes. In contrast, the control group showed only a low level of improvement. This finding reinforces the effectiveness of decision-making-oriented cooperative learning.

Observational Findings

Observational data were analyzed to capture behavioral changes during the learning process. Students in the experimental group demonstrated higher engagement levels compared to those in the control group. They actively participated in group discussions, contributed ideas, and showed greater responsibility in completing tasks. Furthermore, students were more capable of evaluating evidence and justifying their decisions. The structured decision-making stages appeared to facilitate deeper interaction and

collaborative reasoning. In contrast, the control group showed relatively passive behavior, with fewer students actively participating in discussions. Their learning activities were more dependent on teacher guidance rather than peer interaction. This difference in classroom dynamics supports the quantitative findings. The integration of decision-making processes encouraged students to take ownership of their learning. Overall, observational data confirm that the experimental group exhibited stronger development of scientific attitudes.

Discussion

The findings of this study indicate that decision-making-oriented cooperative learning significantly improves students' scientific attitudes, as reflected in higher posttest scores and greater learning gains in the experimental group. This result suggests that integrating structured decision-making processes into cooperative learning creates a more meaningful learning experience. The improvement can be attributed to the active engagement of students in analyzing problems, evaluating alternatives, and making informed decisions. These processes allow students to construct knowledge more deeply compared to passive learning approaches. In addition, the collaborative nature of the learning model supports interaction among students, which enhances their understanding and attitudes toward scientific inquiry (Gillies, 2023; Rohaeti et al., 2020; Tsivitanidou et al., 2021). This finding aligns with previous studies demonstrating that cooperative learning positively influences student engagement and academic outcomes. However, the present study extends these findings by emphasizing the role of decision-making as a structured component within cooperative learning. This integration appears to strengthen both cognitive and affective aspects of learning simultaneously. Therefore, the results confirm that combining cooperative learning with decision-making processes provides a more comprehensive educational approach.

Furthermore, the significant difference between the experimental and control groups highlights the importance of structured learning processes in developing scientific attitudes. While the control group showed some improvement, the increase was relatively lower compared to the experimental group. This suggests that conventional or inquiry-based approaches without explicit decision-making components may not be sufficient to optimize affective learning outcomes (Brumann et al., 2022; Chen & Chen, 2025; Şengül & Karabacak, 2026; Tawfik et al., 2020). Previous research has emphasized that cooperative learning alone can enhance critical thinking and participation, but its effectiveness depends on how it is implemented. Studies indicate that cooperative learning improves students' engagement, conceptual understanding, and higher-order thinking skills when properly structured (Ceballos et al., 2026; Cojorn & Sonsupap, 2024; Lu et al., 2021; Takko et al., 2020). However, without clear guidance, group learning activities may not fully achieve their intended outcomes. The present study addresses this limitation by incorporating decision-making stages that guide students through systematic reasoning. This structured approach enables students to evaluate evidence more critically and make reasoned conclusions. As a result, students are not only engaged in learning but also actively involved in knowledge construction. This supports the idea that instructional design plays a crucial role in determining learning effectiveness. Therefore, the inclusion

of decision-making processes enhances the impact of cooperative learning on scientific attitudes.

In addition, the findings reveal that decision-making-oriented cooperative learning contributes to the development of key components of scientific attitudes, such as curiosity, respect for evidence, and environmental awareness. Students in the experimental group demonstrated greater willingness to explore ideas, ask questions, and evaluate information critically (Walsh et al., 2022). This improvement can be explained by the nature of decision-making activities, which require students to actively engage with problems and consider multiple perspectives. In environmental education contexts, such engagement is particularly important because students are often required to make judgments about complex issues (Derr & Simons, 2020; Herman et al., 2020; Reid et al., 2021). Previous studies have shown that cooperative learning can improve affective outcomes, although the effects may vary depending on implementation. Some research indicates that cooperative learning has a moderate to strong influence on affective learning outcomes, including attitudes and motivation. However, the current findings suggest that integrating decision-making processes can further strengthen these outcomes. This is because decision-making encourages students to take responsibility for their choices and reflect on their reasoning. As a result, students develop a more meaningful connection with the learning material. This supports the argument that affective learning can be enhanced through active and reflective learning strategies. Therefore, decision-making-oriented learning plays a crucial role in shaping students' scientific attitudes.

Moreover, the observational findings support the quantitative results by showing that students in the experimental group were more actively engaged during the learning process. They participated more frequently in discussions, contributed ideas, and demonstrated stronger collaboration within groups. This active participation is a key indicator of effective learning and is closely related to the development of scientific attitudes. In contrast, students in the control group tended to rely more on teacher guidance and showed lower levels of interaction. This difference in behavior suggests that the learning environment plays a significant role in shaping students' attitudes. Previous research has emphasized that cooperative learning environments promote interaction, communication, and social responsibility among students. However, the present study shows that these benefits can be enhanced when decision-making processes are incorporated into the learning structure. The structured decision-making stages provide clear guidance for students, enabling them to participate more effectively in group activities. This also reduces the likelihood of passive participation or dominance by certain individuals. As a result, all students have the opportunity to engage actively in the learning process. This finding highlights the importance of combining interaction with structured reasoning processes. Therefore, decision-making-oriented cooperative learning creates a more dynamic and inclusive learning environment.

Finally, the results of this study contribute to the broader field of science education by addressing the gap between cognitive and affective learning outcomes. While many previous studies have focused primarily on academic achievement and cognitive skills, this study emphasizes the importance of scientific attitudes as an equally critical outcome. The integration of decision-making into cooperative learning provides a framework for

addressing both domains simultaneously. This approach is particularly relevant in the context of environmental education, where students must develop both knowledge and responsibility. Previous literature has highlighted the need for learning models that integrate multiple competencies, including critical thinking, collaboration, and decision-making. However, empirical evidence on how these elements can be effectively combined remains limited. The findings of this study provide evidence that such integration is not only possible but also effective. This suggests that future research should explore similar approaches in different contexts and subject areas. In addition, educators should consider incorporating structured decision-making processes into their teaching practices. This can help create more meaningful and impactful learning experiences for students. Overall, the study demonstrates that decision-making-oriented cooperative learning offers a promising direction for improving science education.

Implication

The findings of this study carry important implications for both instructional practice and the development of science education. The demonstrated effectiveness of decision-making-oriented cooperative learning suggests that educators should move beyond conventional teaching approaches that primarily emphasize content delivery. Integrating structured decision-making processes into classroom activities can provide students with opportunities to engage in deeper cognitive processing while simultaneously developing their scientific attitudes. This approach encourages learners to actively analyze problems, evaluate evidence, and justify their conclusions, which are essential competencies in modern science education. In addition, the use of cooperative learning structures promotes collaboration and social interaction, enabling students to learn from diverse perspectives and build shared understanding. The combination of these elements supports the development of both cognitive and affective domains in a balanced manner. From a curriculum perspective, the findings indicate the need to incorporate decision-making activities as a core component of science learning, particularly in topics related to environmental issues. This integration can help align classroom practices with real-world demands, where individuals are required to make informed and responsible decisions. Furthermore, the approach can foster students' sense of responsibility toward environmental sustainability by encouraging them to consider the consequences of their actions. For teachers, this implies the importance of designing learning scenarios that are problem-based and contextually relevant. It also highlights the need for professional development programs that equip educators with strategies to implement decision-making-oriented instruction effectively. Overall, the study suggests that adopting this instructional model can contribute to the creation of more meaningful, student-centered, and future-oriented learning environments.

Limitation and Suggestion for Further Research

This study has several limitations that should be considered when interpreting the findings and guiding future research. First, the use of a quasi-experimental design without random assignment may limit the generalizability of the results beyond the specific sample involved. Second, the study was conducted in a single school setting, which may not fully represent diverse educational contexts or student populations. Third, the duration of the intervention was relatively short, potentially restricting the extent to which long-term

changes in scientific attitudes could be observed. Fourth, the measurement of scientific attitudes relied primarily on self-reported questionnaires, which may be subject to response bias or social desirability effects. Although observational data were used to support the findings, these observations may still be influenced by subjective interpretation. Additionally, the study focused only on a limited number of indicators of scientific attitudes, which may not capture the full complexity of the construct. Another limitation is that the control group was taught using an inquiry-based approach, which may also promote active learning, thereby reducing the observable contrast between groups. Furthermore, external factors such as students' prior experiences, motivation, and classroom dynamics were not fully controlled. These factors may have influenced the outcomes and should be considered in future studies. Therefore, further research is recommended to involve larger and more diverse samples to improve generalizability. Future studies should also consider using longitudinal designs to examine the sustainability of improvements in scientific attitudes over time. In addition, employing mixed-method approaches that combine quantitative and qualitative data could provide a more comprehensive understanding of how decision-making-oriented cooperative learning influences student learning.

CONCLUSION

This study concludes that decision-making-oriented cooperative learning is an effective instructional approach for enhancing students' scientific attitudes in environmental change education. The findings demonstrate that students exposed to this approach show greater improvement compared to those taught using conventional methods. This improvement reflects the positive impact of integrating structured decision-making processes into collaborative learning environments. Through this approach, students are encouraged to actively engage in problem analysis, evaluate evidence, and make informed decisions. These learning experiences contribute to the development of key components of scientific attitudes, including curiosity, respect for evidence, and environmental awareness. In addition, the cooperative nature of the learning process supports interaction and knowledge sharing among students, which further strengthens learning outcomes. The study also highlights the importance of combining cognitive and affective dimensions in science education. By integrating decision-making into cooperative learning, students are better prepared to apply scientific knowledge in real-world contexts. This approach is particularly relevant in environmental education, where responsible decision-making is essential. Furthermore, the results suggest that instructional strategies play a crucial role in shaping students' attitudes and learning experiences. Therefore, educators are encouraged to adopt more structured and interactive learning models. Overall, this study provides evidence that decision-making-oriented cooperative learning can contribute to more meaningful and effective science education.

AUHOR CONTRIBUTIONS STATEMENT

NA : Conceptualization, research design, development of instruments, data collection, data analysis, and drafting the original manuscript.

YH : Supervision, theoretical framework development, and critical revision of the manuscript for intellectual content.

AS : Data validation, statistical analysis, and interpretation of research findings.
 DRF : Methodological refinement, manuscript editing, and final review for coherence and academic quality.

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