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Phenomenon-based environmental learning for enhancing environmental concepts and sustainability values among primary school students

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ABSTRACT

Developing environmental understanding alongside sustainability-related values has become an important goal of primary education. However, helping young learners connect environmental knowledge to real environmental situations remains a challenge in many classroom settings. This study examined the effectiveness of Phenomenon-Based Environmental Learning in improving environmental concepts and sustainability values among primary school students and explored the relationship between improvements in environmental concepts and improvements in sustainability values. A quasi-experimental pretest-posttest control group design was used. The participants were 70 third-grade students from two public primary schools in Egypt, assigned to an experimental group (n = 35) and a control group (n = 35). The experimental group participated in a researcher-developed Phenomenon-Based Environmental Learning Program consisting of 22 instructional sessions implemented over an 11-week period, while the control group received regular classroom instruction. Data were collected using an Environmental Concepts Test and a Sustainability Values Scale. The results showed statistically significant posttest differences in favor of the experimental group on all dimensions of the Environmental Concepts Test and the Sustainability Values Scale. Effect sizes were large across all dimensions and total scores. The results also showed a statistically significant positive relationship between improvement in environmental concepts and improvement in sustainability values ($r = 0.71$, $p < .001$). The findings suggest that environmental concepts and sustainability values can be developed together when students engage with environmental phenomena through observation, inquiry, discussion, and reflection. Organizing environmental learning around meaningful phenomena may help primary school students develop environmental understanding and sustainability-related values within the same learning experience. The findings provide practical guidance for primary school teachers and curriculum developers seeking to integrate Phenomenon-Based Environmental Learning into primary education.

Keywords: phenomenon-based learning, environmental concepts, sustainability values, environmental education, primary school students

INTRODUCTION

Environmental challenges such as climate change, biodiversity loss, resource depletion, and increasing waste have increased the need for educational approaches that help younger generations understand environmental issues and act responsibly toward their environment. Within the framework of Education for Sustainable Development (ESD), schools are expected to support not only the acquisition of environmental knowledge but also the development of values that shape students' interactions with their social and natural surroundings. Sustainability-related learning has therefore become an important goal across educational stages, particularly during the early years when foundational understandings and values begin to form (Bibi et al., 2026). Environmental education is increasingly expected to promote both environmental awareness and sustainability-oriented attitudes that can influence future behavior (Husin et al., 2025). Sustainability values are also viewed as an important

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educational outcome because they help learners make informed decisions and engage responsibly with environmental and social issues (Karakaş, 2026). This perspective is consistent with Sustainable Development Goal 4 (SDG 4), which emphasizes the role of quality education in developing the knowledge, values, and competencies needed to support sustainable development (Lardhi & Ismail, 2026).

The transition from early childhood to primary education is an important period for developing environmental concepts and sustainability values. During the primary school years, students become increasingly capable of understanding relationships among environmental phenomena, human activities, and sustainability-related challenges (Guerrero & Sjöström, 2025; Husin et al., 2025). At this stage, children begin to build more organized understandings of living organisms, natural resources, environmental protection, and the ways human actions affect the environment. These understandings provide a foundation for later environmental literacy and sustainable decision-making. Environmental concepts and sustainability values should therefore be viewed as closely related educational outcomes rather than separate goals (Naunthong et al., 2026). Environmental concepts help learners understand environmental systems and issues, whereas sustainability values influence how they interpret these issues and respond to them in everyday life (Mardikaningsih & Essa, 2025; Muliana et al., 2026). As noted by Guerrero and Sjöström (2025), environmental literacy involves more than acquiring factual knowledge; it also requires the ability to interpret environmental issues in meaningful ways. Likewise, sustainability-related learning should support students' understanding of ecological systems while encouraging responsibility toward environmental and social well-being (Husin et al., 2025). For this reason, strengthening environmental concepts during primary education can play an important role in fostering sustainability values and supporting long-term engagement with environmental challenges.

Recent research has increasingly emphasized that sustainability education should begin during the early years and continue throughout the primary school stage. This emphasis is based on the view that environmental understanding and sustainability-related values develop gradually through children's interactions with their surroundings, learning experiences, and participation in meaningful activities. Previous studies have shown that sustainability-oriented educational experiences can promote children's environmental understanding while also supporting broader social, emotional, and participatory development (Kahriman-Pamuk & Borg, 2025; Watt & Frydenberg, 2025). Together, these studies suggest that sustainability education extends beyond the transmission of environmental knowledge to fostering children's values, active participation, and responsible engagement with environmental and community issues.

Despite the growing emphasis on environmental education and sustainability, helping students develop meaningful environmental understanding remains a challenge. Traditional instructional approaches often present environmental topics as isolated facts or concepts to be memorized, which may limit students' ability to connect classroom learning with real-world environmental issues. As a result, learners may acquire fragmented knowledge without developing a deeper understanding of environmental relationships or the values needed to address sustainability-related challenges. This concern has encouraged educators and researchers to explore learning approaches that place real-world phenomena at the center of the learning process and engage students in investigating authentic issues rather than simply receiving information (Schaffar & Wolff, 2024).

Phenomenon-Based Learning (PBL) has emerged as one of the approaches that seeks to address these challenges. Originating from educational reforms in Finland, PBL organizes learning around real-world phenomena rather than isolated disciplinary topics, encouraging students to investigate questions, gather information, discuss explanations, and construct knowledge through inquiry and collaboration (Wolff, 2023; Walker & Nouri, 2025). The approach was developed to help learners understand complex issues that cannot be adequately explained through a single subject perspective, making it particularly suitable for environmental and sustainability education, where real-world issues are inherently interconnected (Schaffar & Wolff, 2024). Previous research has also suggested that phenomenon-based learning supports interdisciplinary thinking and promotes key twenty-first-century competencies, including collaboration, critical thinking, problem-solving, and self-directed learning (Habash, 2022; Muhonen & Sankila, 2026).

A growing body of empirical research has reported positive outcomes associated with phenomenon-based learning across different educational contexts. Previous studies have shown that the approach can enhance metacognitive awareness, autonomous learning, and ecoliteracy while encouraging students to connect classroom learning with real-world environmental and sustainability issues (Akkaş & Eker, 2021; Eker, 2026; Heikkilä, 2022; Kadarisman et al., 2023). Collectively, these findings suggest that phenomenon-based learning has the potential to support both conceptual understanding and value-oriented learning, two outcomes that are central to sustainability education.

At the same time, existing research reveals several gaps that warrant further investigation. Much of the available literature has focused on secondary, higher, or teacher education contexts, while fewer studies have examined the application of phenomenon-based learning among primary school students. Existing studies have also tended to investigate outcomes such as metacognition, ecoliteracy, autonomous learning, and student reflections (Akkas & Eker, 2021; Kadarisman et al., 2023; Eker, 2026), with comparatively limited attention given to environmental concepts and sustainability values as complementary learning outcomes. Furthermore, although sustainability values are increasingly recognized as important educational outcomes (Karakaş, 2026), empirical evidence regarding how instructional approaches contribute to their development among younger learners remains limited. Given the importance of primary education in shaping students' environmental understanding and value orientations, there is a need for studies that examine whether phenomenon-based environmental learning can enhance environmental concepts and sustainability values

Table 1. Guiding questions of the preliminary exploratory investigation

Domain	Exploratory Question
Knowledge of PBL	Are you familiar with the principles of Phenomenon-Based Learning?
Knowledge of PBL	Have you previously used Phenomenon-Based Learning in your teaching?
Environmental Concepts	Do you use real environmental phenomena to introduce environmental concepts to students?
Environmental Concepts	Do students investigate environmental issues through observation, inquiry, or problem-solving activities?
Environmental Concepts	Do environmental lessons help students connect concepts to real-life environmental situations?
Sustainability Values	Are sustainability values explicitly addressed during environmental learning activities?
Sustainability Values	Do classroom activities encourage students to discuss responsible environmental behaviors?
Sustainability Values	Do students participate in activities that promote environmental and social responsibility?

simultaneously and explore the relationship between improvements in these two outcomes.

Despite the growing interest in Phenomenon-Based Learning within environmental education, further evidence is needed to better understand its role in developing both environmental concepts and sustainability values among primary school students. Accordingly, the present study addresses this issue through the research problem presented below.

STATEMENT OF THE PROBLEM

Despite the growing emphasis on environmental education and sustainability in school education, many primary school students still experience difficulty developing meaningful environmental concepts and sustainability values (Husin et al., 2025; Karakaş, 2026). Traditional instructional approaches often emphasize the acquisition of environmental knowledge without sufficiently helping students connect environmental concepts with authentic environmental situations or develop the values needed to respond to sustainability-related challenges. This highlights the need for instructional approaches that engage students with real-world environmental phenomena and support meaningful learning.

Phenomenon-Based Learning has been proposed as an instructional approach that connects learning with authentic environmental contexts (Schaffar & Wolff, 2024; Wolff, 2023). However, existing research has focused primarily on outcomes such as metacognitive awareness, autonomous learning, and ecoliteracy (Akkas & Eker, 2021; Kadarisman et al., 2023; Eker, 2026), while comparatively little attention has been given to its effectiveness in enhancing environmental concepts and sustainability values simultaneously among primary school students or to the relationship between these two outcomes.

To gain a clearer understanding of the problem in the target context, the researchers conducted a preliminary exploratory investigation involving 25 third-grade primary school teachers from three public schools in Egypt. The investigation sought to explore teachers' familiarity with Phenomenon-Based Learning (PBL), the extent to which environmental phenomena were used in teaching environmental concepts, and the attention given to sustainability values within classroom practices. The guiding questions used in this exploratory investigation are presented in **Table 1**.

The preliminary indicators obtained from the exploratory investigation conducted by the researchers highlighted several issues relevant to the current study. Approximately 20% of the participating teachers indicated that they were unfamiliar with the concept of Phenomenon-Based Learning, while 70% reported that they rarely or never used environmental phenomena as a basis for teaching environmental concepts. In addition, most participants reported limited attention to the explicit development of sustainability values during environmental lessons and noted that environmental topics were often taught through traditional instructional approaches. The preliminary indicators also suggested weak connections between environmental concepts presented in the classroom and students' everyday environmental experiences. These indicators point to a need for instructional approaches that connect environmental learning to authentic environmental phenomena while supporting the development of both environmental concepts and sustainability values among primary school students.

These preliminary indicators, together with the gaps identified in the literature, demonstrate the need to examine the effectiveness of Phenomenon-Based Environmental Learning in enhancing environmental concepts and sustainability values among primary school students and to investigate the relationship between improvements in these two outcomes. Accordingly, the present study adopted a quasi-experimental design to address this need.

PURPOSE OF THE STUDY

The present study aims to examine the effectiveness of Phenomenon-Based Environmental Learning in enhancing environmental concepts and sustainability values among third-grade primary school students. Specifically, the study investigates its effectiveness in enhancing students' understanding of Living Organisms and Ecosystems, Natural Resources, Environmental Conservation, and Waste and Recycling. It also examines its effectiveness in enhancing Environmental Sustainability Values and Social Sustainability Values. In addition, the study explores the relationship between improvements in environmental concepts and sustainability values among the participating students.

RESEARCH QUESTIONS

RQ1: How effective is Phenomenon-Based Environmental Learning in enhancing environmental concepts among primary school students?

RQ1a: How effective is Phenomenon-Based Environmental Learning in enhancing students' understanding of Living Organisms and Ecosystems?

RQ1b: How effective is Phenomenon-Based Environmental Learning in enhancing students' understanding of Natural Resources?

RQ1c: How effective is Phenomenon-Based Environmental Learning in enhancing students' understanding of Environmental Conservation?

RQ1d: How effective is Phenomenon-Based Environmental Learning in enhancing students' understanding of Waste and Recycling?

RQ2: How effective is Phenomenon-Based Environmental Learning in enhancing sustainability values among primary school students?

RQ2a: How effective is Phenomenon-Based Environmental Learning in enhancing Environmental Sustainability Values?

RQ2b: How effective is Phenomenon-Based Environmental Learning in enhancing Social Sustainability Values?

RQ3: Is the improvement in environmental concepts associated with the improvement in sustainability values among primary school students?

LITERATURE REVIEW

Phenomenon-Based Environmental Learning

Phenomenon-Based Learning (PBL) is an instructional approach that organizes learning around meaningful real-world phenomena rather than isolated disciplinary topics. Instead of studying concepts separately within subject boundaries, students investigate authentic phenomena that require knowledge and perspectives from multiple disciplines to understand and explain them (Wolff, 2023; Schaffar & Wolff, 2024). Recent reviews describe PBL as a learner-centered approach that engages students in observing phenomena, asking questions, gathering information, analyzing evidence, constructing explanations, and reflecting on their learning through inquiry and collaboration (Anisa et al., 2026; Marvi et al., 2025). Originally developed within the context of educational reforms in Finland, PBL was introduced to help learners understand complex contemporary issues that cannot be adequately addressed through a single subject perspective (Schaffar & Wolff, 2024).

Phenomenon-Based Environmental Learning is conceptually grounded in the premise that meaningful learning occurs when students actively engage with authentic environmental phenomena rather than learning isolated concepts through direct instruction. The learning process typically begins with observing and questioning real-world environmental phenomena, followed by inquiry, information gathering, collaborative discussion, concept construction, application, and reflection. Through this sequence, students are expected to construct environmental understanding by connecting new knowledge with authentic environmental situations while simultaneously developing the values that guide responsible environmental decision-making (Schaffar & Wolff, 2024; Walker & Nouri, 2025; Wolff, 2023). From this perspective, environmental concepts and sustainability values are viewed as complementary learning outcomes that develop together through students' active interaction with meaningful environmental phenomena, making Phenomenon-Based Environmental Learning particularly suitable for environmental and sustainability education.

A defining characteristic of Phenomenon-Based Environmental Learning is the use of authentic environmental phenomena as the starting point for learning. Rather than introducing environmental concepts as isolated topics, students investigate observable environmental events and issues that require them to examine relationships among natural systems, human activities, and sustainability-related challenges. This process encourages learners to connect classroom learning with real-life experiences, making environmental concepts more meaningful and applicable (Meechandee & Meekaew, 2025). Likewise, phenomenon-based science education has been shown to support deeper understanding by helping students relate scientific ideas to authentic contexts and explore the complex relationships underlying environmental phenomena (Saberi & Nouri, 2025). Contemporary educational approaches also emphasize the importance of engaging learners with real-world challenges that foster interdisciplinary thinking and prepare them to address increasingly complex environmental and societal issues (Habash, 2022). Accordingly, environmental education provides a particularly appropriate context for implementing Phenomenon-Based Learning because environmental issues naturally require the integration of knowledge, inquiry, and value-based decision-making.

Recent empirical research has provided growing support for the conceptual assumptions underlying Phenomenon-Based Learning across a variety of educational contexts. Collectively, previous studies have shown that the approach contributes to the development of scientific literacy, student engagement, critical thinking, creative thinking, communication, collaboration, and broader learning competencies (Marvi et al., 2025; Meechandee & Meekaew, 2025; Khatimah et al., 2026; Khuana et al., 2025; Klomim et al., 2024; Oktobianti et al., 2026; Ualikhanova et al., 2024; Yanti et al., 2024). Other studies have also reported positive effects on metacognitive awareness, autonomous learning, ecoliteracy, and students' reflections on sustainability-related issues (Akkaş & Eker, 2021; Heikkilä, 2022; Kadarisman et al., 2023; Eker, 2026). Taken together, these findings suggest that Phenomenon-Based Learning provides a learning environment that supports both conceptual development and value-oriented learning. This evidence is consistent with the conceptual foundation presented earlier and supports the use of Phenomenon-Based Environmental Learning as an appropriate approach for simultaneously enhancing environmental concepts and sustainability values among primary school students.

Figure 1 summarizes the conceptual sequence of Phenomenon-Based Learning described in the literature. Although implementation may vary across educational contexts, the approach generally begins with a meaningful real-world phenomenon and progresses through inquiry, investigation, analysis, explanation, communication, and

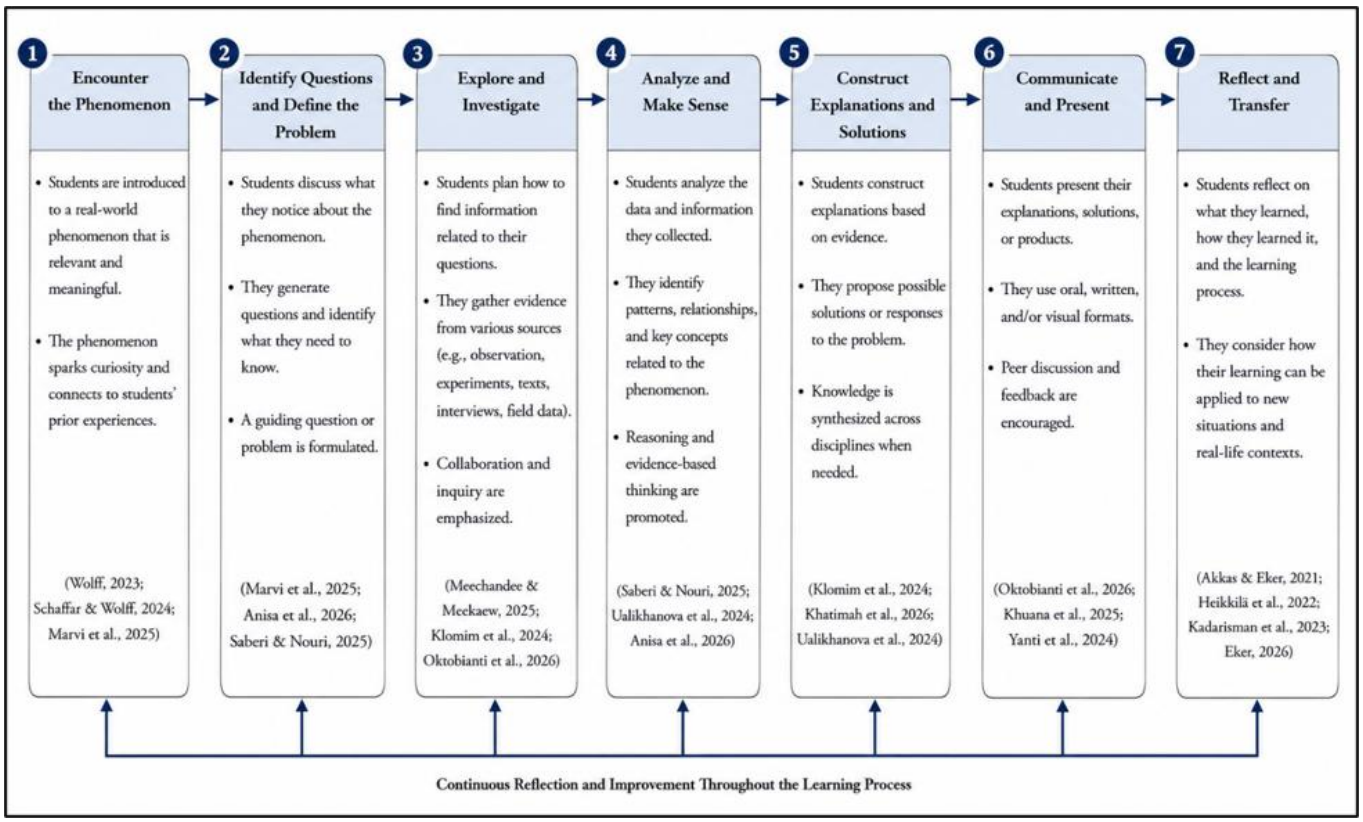


Figure 1. Main stages of phenomenon-based learning (Source: Authors' own elaboration)

reflection. Together, these stages illustrate the conceptual process through which students develop understanding by actively engaging with authentic phenomena.

As shown in **Figure 1**, Phenomenon-Based Learning places meaningful real-world phenomena at the center of the learning process. Students progress from identifying and investigating a phenomenon to constructing explanations, applying their understanding, and reflecting on their learning. This conceptual sequence encourages active participation, inquiry, collaboration, and evidence-based reasoning, creating opportunities for students to develop environmental concepts while simultaneously strengthening sustainability values. The instructional program developed for the present study was designed around these core principles and adapted to the environmental topics and learning needs of third-grade primary school students.

Consistent with the principles of Phenomenon-Based Learning, the teacher primarily acts as a facilitator who guides inquiry rather than directly transmitting knowledge. The teacher helps students identify meaningful questions, organize learning activities, provide appropriate learning resources, and support discussion and reflection throughout the learning process (Habash, 2022; Walker & Nouri, 2025; Muhonen & Sankila, 2026). At the same time, the teacher monitors students' progress, provides timely guidance, and encourages active participation and collaborative learning.

Within this learning process, students take an active role in investigating environmental phenomena by asking questions, collecting and analyzing information, discussing ideas with peers, and constructing explanations based on evidence. Rather than receiving information passively, they participate in inquiry, collaboration, application, and reflection throughout the learning process (Schaffar & Wolff, 2024; Walker & Nouri, 2025; Wolff, 2023). These complementary roles of teachers and students are central to the successful implementation of Phenomenon-Based Learning across different educational contexts.

Environmental Concepts and Sustainability Values

Environmental concepts represent a fundamental component of environmental education because they help learners understand relationships among living organisms, natural resources, environmental systems, and human activities. These concepts provide the knowledge base needed for interpreting environmental issues and making informed decisions about environmental practices. Previous studies have emphasized that meaningful learning of environmental concepts requires instructional approaches that connect scientific knowledge to real-life contexts rather than relying solely on the transmission of information (Melesse et al., 2025; Rezghi Shirsavar & Salami, 2023). Research has also shown that students develop stronger environmental understanding when learning experiences are linked to authentic situations and observable phenomena (Paivandi et al., 2024). In addition, environmental concepts are increasingly viewed as an important foundation for environmental literacy and sustainable decision-making (Guerrero & Sjöström, 2025). For the purposes of the present study, environmental concepts are represented through four dimensions: Living Organisms and Ecosystems, Natural Resources, Environmental Conservation, and Waste and Recycling.

Alongside conceptual understanding, sustainability education seeks to develop values that guide learners' attitudes and behaviors toward environmental and social issues. Sustainability values refer to principles and beliefs that

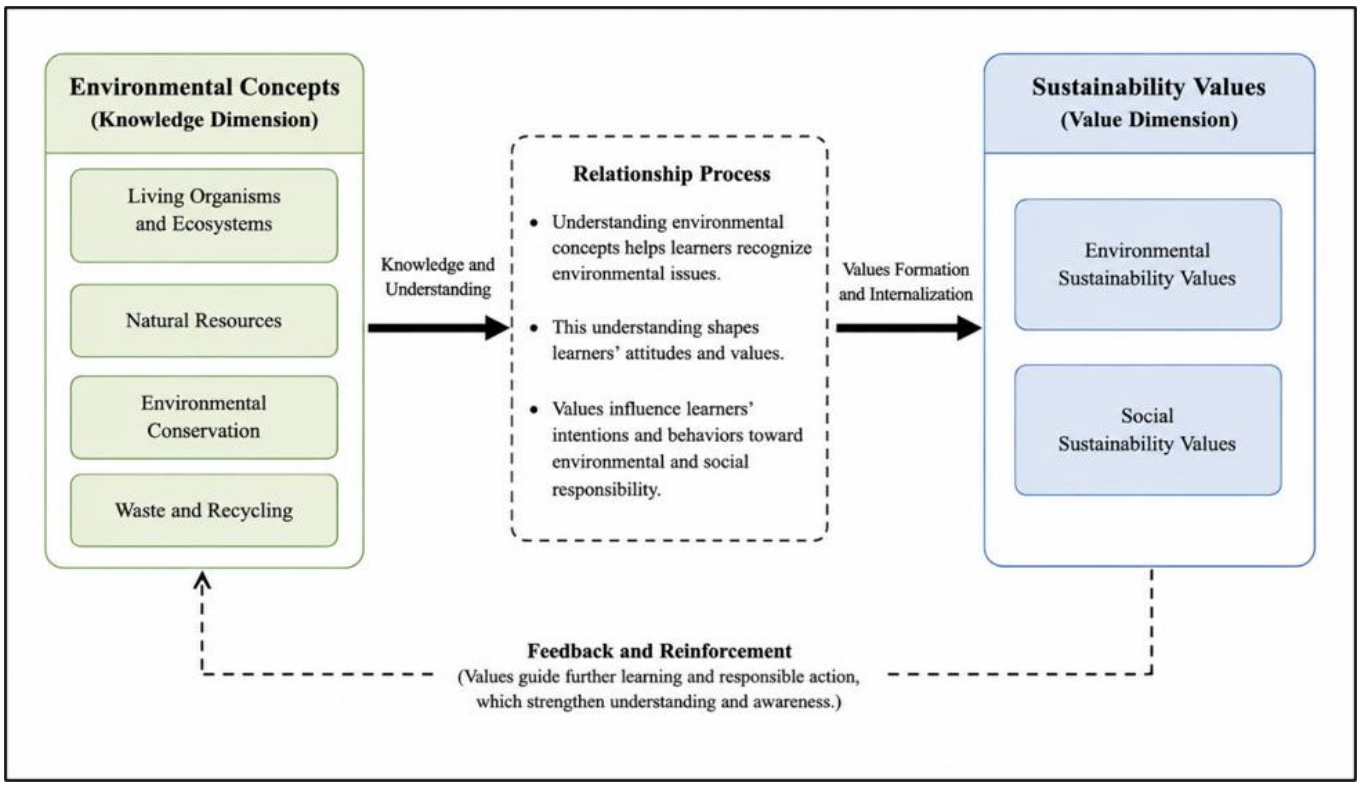


Figure 2. Conceptual relationship between environmental concepts and sustainability values (Source: Authors' own elaboration)

support responsible actions, long-term thinking, and concern for environmental and societal well-being (Ahrens et al., 2024; Kondrla, 2023). Recent studies have highlighted the growing importance of sustainability values in educational contexts because they influence how individuals interpret sustainability-related issues and respond to them in everyday life (Kristia et al., 2024; Naunthong et al., 2026). Research has also suggested that sustainability values can be strengthened through educational experiences that encourage participation, responsibility, and engagement with real-world issues (Kondrla et al., 2024). In the present study, sustainability values are examined through two dimensions: Environmental Sustainability Values and Social Sustainability Values.

Environmental concepts and sustainability values are closely related. Conceptual understanding helps learners recognize environmental issues and understand their causes and consequences, while sustainability values influence how learners evaluate these issues and act in response to them. Crase et al. (2024) argued that environmental understanding alone may not be sufficient unless individuals also value environmental protection and sustainable practices. Similarly, environmental education research has emphasized the importance of integrating knowledge and values within learning experiences that encourage students to connect environmental understanding with responsible action (Bibi et al., 2026; Husin et al., 2025). From this perspective, educational approaches that engage learners in investigating authentic environmental phenomena may contribute not only to the development of environmental concepts but also to the strengthening of sustainability values.

Figure 2 presents the conceptual relationship between environmental concepts and sustainability values based on the literature reviewed in this study. The figure illustrates how environmental understanding can contribute to the development of sustainability values and how these values may, in turn, support responsible environmental and social behaviors.

Environmental concepts and sustainability values are closely connected. Understanding environmental issues provides a foundation for developing sustainability-oriented values, while these values can encourage learners to apply their knowledge in responsible ways. The relationship is not viewed as one-directional; rather, greater environmental understanding may strengthen sustainability values, and stronger values may further support environmental awareness and learning. This relationship provides a theoretical basis for examining both variables together in the present study.

Beyond its importance within the present study, developing environmental concepts and sustainability values reflects broader priorities in contemporary education. Internationally, environmental education is increasingly viewed as an essential component of Education for Sustainable Development, as it helps learners develop the knowledge, values, and responsible behaviors needed to address current and future environmental challenges (Bibi et al., 2026; Husin et al., 2025). In this context, strengthening environmental concepts and sustainability values among primary school students supports the educational aspirations of Sustainable Development Goal 4 (Quality Education), particularly those related to preparing learners to contribute to sustainable development through meaningful learning experiences (Lardhi & Ismail, 2026). It also contributes to the broader objectives of Sustainable Development Goal 13 (Climate Action) by fostering environmental awareness and encouraging environmentally responsible behavior from an early age.

The instructional design adopted in the present study is also consistent with the international principles of Phenomenon-Based Learning, which were originally developed and widely implemented in the Finnish educational system. This approach emphasizes learning through authentic real-world phenomena, student inquiry, collaboration, and the integration of knowledge across subject areas rather than learning isolated concepts separately (Schaffar & Wolff, 2024; Wolff, 2023). By engaging primary school students in investigating environmental phenomena, discussing possible explanations, and applying their learning to everyday environmental situations, the proposed program reflects these principles while adapting them to the Egyptian primary school context (Heikkilä, 2022; Walker & Nouri, 2025).

Previous Research and Research Gap

Previous research has reported positive outcomes of Phenomenon-Based Learning across different educational contexts. Studies have shown that the approach can enhance scientific literacy, critical thinking, communication, collaboration, metacognitive awareness, autonomous learning, and student engagement (Akkas & Eker, 2021; Marvi et al., 2025; Meechandee & Meekaew, 2025; Ualikhanova et al., 2024; Khuana et al., 2025; Khatimah et al., 2026; Oktobianti et al., 2026; Eker, 2026). Other studies have emphasized the importance of authentic environmental contexts for developing environmental understanding, ecoliteracy, and sustainability-related values (Kadarisman et al., 2023; Paivandi et al., 2024; Crase et al., 2024; Guerrero & Sjöström, 2025; Melesse et al., 2025; Ahrens et al., 2024; Husin et al., 2025; Karakaş, 2026).

Despite these contributions, several gaps remain. Most studies on Phenomenon-Based Learning have focused on general learning outcomes rather than environmental concepts and sustainability values as the primary outcomes of instruction. In addition, environmental concepts and sustainability values have often been investigated separately, with relatively few studies examining both outcomes within the same instructional intervention. Research involving primary school students is also limited, as most studies have been conducted in secondary, higher, or teacher education contexts. Furthermore, few studies have examined the relationship between environmental concepts and sustainability values following a Phenomenon-Based Environmental Learning intervention.

The present study addresses these gaps by examining the effectiveness of Phenomenon-Based Environmental Learning in enhancing environmental concepts and sustainability values among third-grade primary school students. It also investigates the relationship between improvements in these two outcomes using a quasi-experimental design.

MATERIALS AND METHODS

Research Design

This study employed a quasi-experimental pretest-posttest control group design. Quasi-experimental designs are widely used in educational research when full random assignment is difficult to implement because of practical and educational considerations within authentic school settings (Lodico et al., 2010; Wallen & Fraenkel, 2013). This design was considered appropriate for the present study because it allowed the researchers to examine the effectiveness of an educational intervention while maintaining the natural conditions of the school environment.

The study involved an experimental group and a control group. Assignment to the study conditions was conducted at the school level rather than at the individual student level. One participating school served as the experimental group, whereas the other served as the control group. This approach was adopted to maintain the normal organization of the schools and to minimize interaction between the two groups during the implementation of the intervention. Both groups completed the Environmental Concepts Test and the Sustainability Values Scale before and after the intervention. The experimental group received instruction through a Phenomenon-Based Environmental Learning program developed by the researchers, whereas the control group received instruction through the regular teaching approach used in their school. Although both groups studied the same environmental content, the difference between them was related to the instructional approach used to present and organize learning experiences. The design of the study is presented in **Figure 3**.

Participants

The participants were 70 third-grade primary school students drawn from two public primary schools in Egypt. The names of the schools are not reported to protect confidentiality. The two schools were purposively selected because they followed the national curriculum prescribed by the Ministry of Education, operated under broadly similar educational conditions in terms of grade level, school type, and instructional context, and agreed to participate in the study. Both schools were located in the same city.

The study focused on third-grade students because the environmental topics addressed in the instructional program are included in the Grade 3 curriculum, and students at this stage are developmentally able to engage in observation, inquiry, discussion, and collaborative learning activities.

Within each school, a simple random sampling procedure was used to select the participating students. Lists containing the names of all third-grade students were obtained from the school administrations, and each student was assigned a number. Participants were then selected through random draws until the required sample size was reached. The final sample consisted of 70 students with a mean age of 8.6 years. The experimental school included 35 students, and the control school included 35 students. **Table 2** presents the demographic characteristics of the participants.

The equivalence of the two groups was examined prior to the intervention using the pretest scores of the Environmental Concepts Test and the Sustainability Values Scale. The results of the equivalence analysis are reported in Section *Group Equivalence*.

Research Instruments

Two research instruments were used to collect the study data: The Environmental Concepts Test and the Sustainability

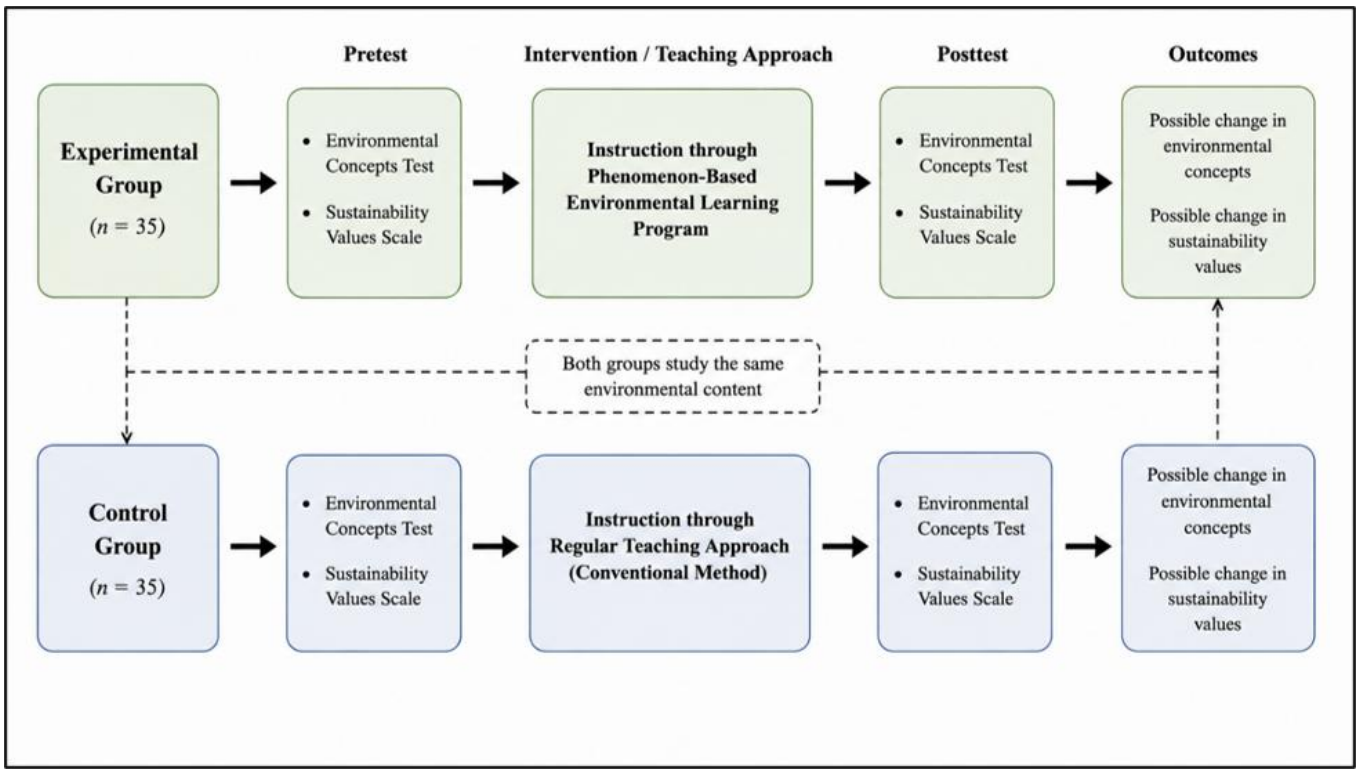


Figure 3. Overview of the research design (Source: Authors' own elaboration)

Table 2. Demographic characteristics of the participants

School	Group	Boys	Girls	Total	Mean Age
School 1*	Experimental	16	19	35	8.6
School 2*	Control	15	20	35	
Total	—	31	39	70	

* School names are concealed for ethical considerations.

Values Scale. Both instruments were developed by the researchers specifically for the purposes of the present study and were subjected to procedures to establish their validity and reliability before implementation.

Environmental concepts test

The Environmental Concepts Test was developed by the researchers to assess third-grade primary school students' understanding of the environmental concepts targeted in the study. The test focused on four domains: Living Organisms and Ecosystems, Natural Resources, Environmental Conservation, and Waste and Recycling. These domains were selected because they represent key environmental topics included in the instructional program and are appropriate for students at this educational stage.

The initial version of the test consisted of 17 multiple-choice items covering the four domains. The items were written in Arabic because the participants were Arabic-speaking students enrolled in Egyptian public schools where Arabic is the language of instruction. Care was taken to use simple wording and short sentences suitable for third-grade students. Each item included four alternatives, with one correct answer.

Two formats of items were used. In the first format, students were presented with a concept and asked to identify the option that best represented its application. An example of this format is shown below:

Which of the following actions best reflects environmental conservation?

a. Reusing a water bottle several times before replacing it
b. Leaving classroom lights on during recess
c. Throwing recyclable materials into general waste bins
d. Using more paper than necessary during school activities

In the second format, a definition or description of a concept was presented in the question stem, and students were asked to identify the concept from a set of alternatives. An example of this format is shown below:

What is the name of the process of collecting used materials and turning them into new products?

a. Environmental Conservation
b. Recycling
c. Natural Resources
d. Ecosystem

Validity: To examine content validity, the initial version of the test was reviewed by five specialists in curriculum and instruction, science education, environmental education, and educational measurement. The reviewers examined the relevance of the items to the intended domains, the clarity of

Table 3. Examples of sustainability values scale statements and response format

Dimension	Example Statement	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
Environmental Sustainability Values	I turn off the water tap when I finish using it.					
Environmental Sustainability Values	I put waste in the correct place to keep the environment clean.					
Social Sustainability Values	I cooperate with my classmates when working in groups.					
Social Sustainability Values	I help other students when they need support.					

wording, the suitability of the items for third-grade students, and the appropriateness of the response alternatives. Based on their comments, minor revisions were made to the wording of some items and alternatives to improve clarity. The reviewers agreed that the test adequately represented the targeted domains and was suitable for the study sample.

Reliability: The test was piloted with 10 third-grade students who were not included in the main study sample. The pilot administration helped ensure that the instructions and items were clear and understandable for students at this age level. Cronbach's alpha coefficients were calculated for each domain and for the test as a whole. The obtained coefficients were 0.86 for Living Organisms and Ecosystems, 0.79 for Natural Resources, .81 for Environmental Conservation, and 0.82 for Waste and Recycling. The overall reliability coefficient was 0.82.

The results of the validity and reliability procedures did not indicate the need to remove or modify any items. Therefore, all 17 items were retained in the final version of the test and were used in the main study.

Scoring: Each correct answer was awarded one point, while incorrect answers received zero points. The total score therefore ranged from 0 to 17, with higher scores indicating a higher level of understanding of environmental concepts.

Sustainability values scale

The Sustainability Values Scale was developed by the researchers to assess sustainability values among third-grade primary school students. The scale was designed to measure two dimensions that were consistent with the objectives of the study: Environmental Sustainability Values and Social Sustainability Values. The development of the scale was informed by the literature on sustainability values and sustainability education, which emphasizes the importance of fostering environmentally responsible behaviors alongside positive social attitudes and participation (Kondrla, 2023; Ahrens et al., 2024; Husin et al., 2025). Previous studies have also highlighted the role of sustainability values in shaping how individuals understand and respond to environmental and social issues (Karakaş, 2026; Naunthong et al., 2026).

The scale consisted of 22 statements distributed across the two dimensions. The Environmental Sustainability Values dimension included 10 statements, whereas the Social Sustainability Values dimension included 12 statements. The statements were written in Arabic because the participants were students in Egyptian public schools where Arabic is the language of instruction. Particular attention was given to the use of simple and age-appropriate language that could be understood by third-grade students.

Students responded to the statements using a five-point Likert scale ranging from 1 (Never) to 5 (Always). The statements focused on everyday behaviors and attitudes related to caring for the environment, conserving resources, maintaining cleanliness, cooperating with others, helping peers, respecting community rules, and participating in activities that benefit the school and the local community. Examples of the statements and the response format used in the scale are presented in **Table 3**.

Validity: To examine content validity, the initial version of the scale was reviewed by five specialists in curriculum and instruction, environmental education, educational psychology, and educational measurement. The reviewers evaluated the relevance of the statements to the intended dimensions, the clarity of wording, and their suitability for third-grade students. Based on their feedback, minor revisions were made to the wording of several statements. The reviewers agreed that the scale adequately represented the two dimensions targeted in the study.

Internal Consistency and Reliability: The scale was piloted with 10 third-grade students who were not included in the main study sample. Internal consistency was examined by calculating the correlations between each dimension and the total score of the scale. Reliability was estimated using Cronbach's alpha coefficients.

The results showed strong correlations between the two dimensions and the total scale score, indicating that both dimensions contributed to the measurement of sustainability values. Cronbach's alpha coefficients also indicated acceptable levels of reliability. The results of the validity and reliability analyses did not indicate the need to remove any statements; therefore, all 22 statements were retained in the final version of the scale. The results are presented in **Table 4**.

Scoring: Responses were scored on a five-point scale ranging from 1 (Never) to 5 (Always). Scores were calculated for each dimension separately and for the scale as a whole. Higher scores indicated higher levels of sustainability values.

Intervention Procedures

Purpose of the phenomenon-based environmental learning program

The Phenomenon-Based Environmental Learning Program was developed to enhance environmental concepts and sustainability values among third-grade primary school students. The program focused on helping students explore environmental issues through direct engagement with real-world phenomena rather than through the presentation of information alone.

Table 4. Internal consistency and reliability indicators of the sustainability values scale

Dimension	Number of Items	Correlation with Total Score	Cronbach's Alpha
Environmental Sustainability Values	10	0.86	0.84
Social Sustainability Values	12	0.89	0.87
Overall Scale	22	-	0.86

The program addressed the four environmental concept domains adopted in the study: Living Organisms and Ecosystems, Natural Resources, Environmental Conservation, and Waste and Recycling. It also aimed to support the development of Environmental Sustainability Values and Social Sustainability Values through activities that encouraged observation, inquiry, discussion, collaboration, and responsible action.

Foundation of the Program: The program was based on the principles of Phenomenon-Based Learning, which view learning as a process of exploring meaningful real-world phenomena through observation, questioning, investigation, discussion, and reflection. Environmental phenomena were used as the starting point for learning activities, allowing students to connect environmental concepts with situations they encounter in their daily lives.

The design of the program was informed by the literature on Phenomenon-Based Learning and environmental education discussed earlier in the study (Eker, 2026; Kadarisman et al., 2023; Schaffar & Wolff, 2024; Wolff, 2023). Particular attention was given to providing opportunities for students to investigate environmental issues, discuss possible solutions, and reflect on environmentally responsible behaviors.

Duration and organization of sessions

The program consisted of 22 instructional sessions implemented over 11 weeks during the second semester of the 2025–2026 academic year. Two sessions were conducted each week. Session duration ranged from approximately 60 to 75 minutes depending on the nature of the activities and the environmental phenomenon being explored. The duration of the program was considered appropriate because it provided students with repeated opportunities to engage in observation, inquiry, discussion, collaborative learning, and reflection across a range of environmental phenomena, while remaining feasible within the regular school schedule. Activities included observation tasks, guided inquiry, classroom discussions, simple investigations, collaborative learning activities, environmental problem-solving tasks, and reflection exercises.

Students' learning outcomes were assessed using two researcher-developed instruments: the Environmental Concepts Test and the Sustainability Values Scale. The Environmental Concepts Test assessed students' understanding of the environmental concepts addressed in the instructional program, whereas the Sustainability Values Scale assessed students' demonstration of sustainability-related values aligned with the program objectives. Both instruments were administered to the experimental and control groups as pre-tests before the intervention and as post-tests immediately after its completion using the same administration procedures. The development, scoring procedures, validity, and reliability of both instruments are described in the following sections.

Throughout the intervention, the researchers monitored the implementation process through regular communication with the teacher and periodic follow-up during the implementation period. Monitoring focused on ensuring that the instructional sessions were delivered according to the teacher's guide, that the planned learning activities were completed as intended, and that the instructional procedures were implemented consistently across sessions. Ongoing support was provided whenever clarification or guidance was needed.

Instructional procedures in the experimental and control groups

The experimental group received instruction through the Phenomenon-Based Environmental Learning Program developed by the researchers. Learning activities were organized around environmental phenomena that were relevant to students' everyday experiences. Students were encouraged to observe, ask questions, collect information, discuss explanations, and connect environmental concepts to real-life situations.

The instructional sessions for the experimental group were delivered by a third-grade primary school teacher from the participating school. Prior to the implementation of the program, the teacher received training from the researchers on the principles of Phenomenon-Based Environmental Learning, the objectives of the program, the organization of instructional activities, and the procedures to be followed during the intervention period. The training included a detailed orientation to the teacher's guide, the instructional sequence of the program, the purpose of each learning activity, and the procedures for implementing the sessions as planned. The training also included guidance on facilitating classroom discussions, supporting student inquiry, and implementing the learning activities consistently across sessions. To promote consistency in implementation and reduce potential instructional bias, the teacher was asked to follow the teacher's guide throughout the intervention and to implement the planned activities without introducing additional instructional strategies or content beyond those specified in the program. Throughout the intervention, the researchers monitored the implementation process and provided ongoing support when needed to ensure adherence to the planned instructional procedures.

The control group was taught by another third-grade teacher from the participating school. Instruction was delivered using the regular teaching approach commonly followed in environmental lessons. This approach relied mainly on teacher explanation, textbook-based activities, classroom questioning, and direct presentation of information. Both groups studied the same environmental content during the same period and completed the same

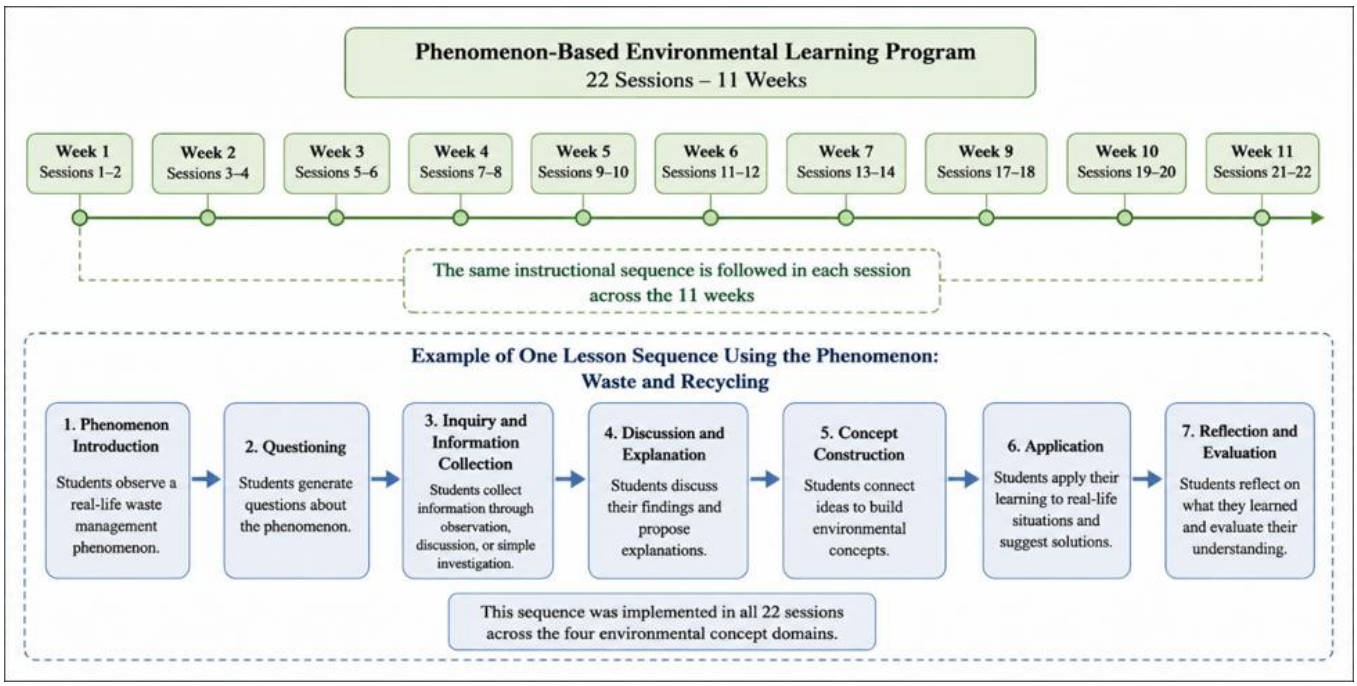


Figure 4. Instructional sequence of the phenomenon-based environmental learning program (Source: Authors' own elaboration)

Table 5. Instructional framework of the phenomenon-based environmental learning program

Week	Session	Environmental Phenomenon	Environmental Concepts Focus	Sustainability Values Focus
1	1	Why do plants grow differently in different places?	Living Organisms and Ecosystems	Caring for living things
1	2	What do plants need to survive?	Living Organisms and Ecosystems	Responsibility toward nature
2	3	Why do some animals live in gardens while others do not?	Living Organisms and Ecosystems	Respect for living organisms
2	4	How do living things depend on each other?	Living Organisms and Ecosystems	Cooperation and interdependence
3	5	Where does our water come from?	Natural Resources	Appreciation of natural resources
3	6	Why should we save water?	Natural Resources	Environmental responsibility
4	7	How do we use natural resources every day?	Natural Resources	Responsible consumption
4	8	What happens when resources are wasted?	Natural Resources	Resource conservation
5	9	Why do trees matter in our environment?	Environmental Conservation	Caring for the environment
5	10	What happens when green areas disappear?	Environmental Conservation	Environmental awareness
6	11	Why should we protect animals and plants?	Environmental Conservation	Respect for biodiversity
6	12	How can children help protect the environment?	Environmental Conservation	Personal responsibility
7	13	Why does waste accumulate in some places?	Waste and Recycling	Environmental responsibility
7	14	What problems can waste cause?	Waste and Recycling	Community responsibility
8	15	Which materials can be recycled?	Waste and Recycling	Sustainable behavior
8	16	What happens to waste after it leaves our homes?	Waste and Recycling	Responsible disposal
9	17	How can we reduce waste at school?	Waste and Recycling	Participation and cooperation
9	18	How can we keep our school environment clean?	Environmental Conservation	Social responsibility
10	19	How can we use water and energy wisely?	Natural Resources	Environmental sustainability values
10	20	How can we work together to improve our environment?	Environmental Conservation	Social sustainability values
11	21	Integrated environmental investigation project	All domains	Integrated sustainability values
11	22	Reflection, presentation, and discussion of findings	All domains	Integrated sustainability values

assessment procedures. The primary difference between the two groups was the instructional approach used during teaching.

Figure 4 illustrates the instructional sequence followed during the implementation of each instructional session. Although the environmental phenomena varied across the 22 sessions, all lessons followed the same pedagogical cycle, beginning with the exploration of a real-world environmental phenomenon and progressing through inquiry, collaborative learning, concept construction, application, and reflection. **Table 5** then presents the environmental phenomena, conceptual focus, and sustainability values addressed across the 22 instructional sessions implemented with the experimental group.

Table 6. Group equivalence on the environmental concepts test (Pretest)

Dimension	Experimental M (SD)	Control M (SD)	t	p
Living Organisms and Ecosystems (4)	2.19 (0.71)	2.11 (0.68)	0.49	0.626
Natural Resources (4)	2.06 (0.74)	1.97 (0.69)	0.53	0.599
Environmental Conservation (5)	2.48 (0.83)	2.34 (0.79)	0.72	0.473
Waste and Recycling (4)	1.82 (0.66)	1.74 (0.63)	0.52	0.605
Total Score (17)	8.55 (2.08)	8.16 (1.97)	0.80	0.427

Table 7. Group equivalence on the sustainability values scale (Pretest)

Dimension	Experimental M (SD)	Control M (SD)	t	p
Environmental Sustainability Values (10–50)	30.91 (4.38)	30.17 (4.25)	0.72	0.474
Social Sustainability Values (12–60)	36.86 (5.12)	35.94 (4.89)	0.77	0.444
Total Score (22–110)	67.77 (8.31)	66.11 (8.02)	0.85	0.399

Table 5 presents the instructional framework of the Phenomenon-Based Environmental Learning Program implemented with the experimental group.

Data Collection Procedures and Data Analysis

Data collection was conducted during the second semester of the 2025–2026 academic year. Before implementing the intervention, the Environmental Concepts Test and the Sustainability Values Scale were administered to both the experimental and control groups to obtain baseline measures and examine group equivalence. Following the pretesting phase, the Phenomenon-Based Environmental Learning Program was implemented with the experimental group over an 11-week period comprising 22 instructional sessions. During the same period, the control group studied the same environmental content using the regular teaching approach followed in the participating school. At the end of the intervention, both instruments were administered again to the experimental and control groups under similar conditions. The collected data were then coded and prepared for statistical analysis.

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS). Means and standard deviations were calculated for all study variables.

To examine group equivalence before the intervention, independent-samples t-tests were conducted using the pretest scores of the Environmental Concepts Test and the Sustainability Values Scale.

To answer RQ1 and its sub-questions concerning the effectiveness of Phenomenon-Based Environmental Learning in enhancing environmental concepts and their dimensions (Living Organisms and Ecosystems, Natural Resources, Environmental Conservation, and Waste and Recycling), independent-samples t-tests were used to compare the posttest scores of the experimental and control groups.

To answer RQ2 and its sub-questions concerning the effectiveness of Phenomenon-Based Environmental Learning in enhancing sustainability values and their dimensions (Environmental Sustainability Values and Social Sustainability Values), independent-samples t-tests were also used to compare the posttest scores of the two groups.

To examine the extent of change within the experimental group between the pretest and posttest administrations, paired-samples t-tests were conducted for the Environmental Concepts Test and the Sustainability Values Scale.

To answer RQ3, which examined whether improvement in environmental concepts was associated with improvement in sustainability values, Pearson correlation coefficients were calculated using the gain scores (posttest score minus pretest score) obtained for the two variables.

In addition, Cohen's d was calculated to determine the magnitude of the observed effects. Statistical significance was determined at the .05 level.

Group Equivalence

Before implementing the intervention, the Environmental Concepts Test and the Sustainability Values Scale were administered to both groups to examine their equivalence on the study variables. Independent-samples t-tests were conducted using the pretest scores of the two groups.

Table 6 presents the pretest results for the Environmental Concepts Test. The results showed no statistically significant differences between the experimental and control groups on any of the four dimensions or on the total test score, indicating that the two groups were comparable in their environmental concepts prior to the intervention.

Table 7 presents the pretest results for the Sustainability Values Scale. The findings showed no statistically significant differences between the experimental and control groups on either dimension of the scale or on the total score. These results suggest that the two groups had similar levels of sustainability values before the intervention began.

Overall, the pretest results indicated that there were no statistically significant differences between the experimental and control groups on the study measures before the implementation of the Phenomenon-Based Environmental Learning Program. Therefore, the two groups were considered equivalent at baseline, allowing subsequent differences observed in the posttest phase to be interpreted in relation to the intervention.

RESULTS

Results Related to RQ1: How Effective is Phenomenon-Based Environmental Learning in Enhancing Environmental Concepts among Primary School Students?

To answer RQ1 and its four sub-questions, independent-samples t-tests were conducted to compare the posttest scores

Table 8. Posttest differences between the experimental and control groups on the environmental concepts test

Dimension	Experimental M (SD)	Control M (SD)	t	p	Cohen's d
Living Organisms and Ecosystems (4)	3.56 (0.51)	2.49 (0.72)	7.25	< .001	1.73
Natural Resources (4)	3.42 (0.60)	2.31 (0.70)	7.11	< .001	1.69
Environmental Conservation (5)	4.18 (0.63)	2.87 (0.81)	7.62	< .001	1.82
Waste and Recycling (4)	3.39 (0.58)	2.15 (0.74)	7.82	< .001	1.87
Total Score (17)	**14.55 (1.64)**	**9.82 (2.07)**	**10.68**	**< .001**	**2.55**

Table 9. Posttest differences between the experimental and control groups on the sustainability values scale

Dimension	Experimental M (SD)	Control M (SD)	t	p	Cohen's d
Environmental Sustainability Values (10–50)	43.77 (3.89)	34.26 (5.18)	7.84	< .001	1.99
Social Sustainability Values (12–60)	51.49 (4.72)	41.86 (5.94)	7.36	< .001	1.81
Total Score (22–110)	**95.26 (7.41)**	**76.11 (9.54)**	**8.69**	**< .001**	**2.10**

of the experimental and control groups on the Environmental Concepts Test. The analysis examined four dimensions: Living Organisms and Ecosystems, Natural Resources, Environmental Conservation, and Waste and Recycling, in addition to the total test score. The results are presented in **Table 8**.

As shown in **Table 8**, the experimental group achieved higher posttest scores than the control group across all four dimensions of the Environmental Concepts Test. All differences were statistically significant ($p < .001$), and the effect sizes were large, indicating substantial differences between the two groups.

- For RQ1a, concerning Living Organisms and Ecosystems, the experimental group achieved a higher mean score ($M = 3.56$, $SD = 0.51$) than the control group ($M = 2.49$, $SD = 0.72$), with a statistically significant difference, $t(68) = 7.25$, $p < .001$. The effect size was large ($d = 1.73$).
- For RQ1b, concerning Natural Resources, the experimental group obtained a higher mean score ($M = 3.42$, $SD = 0.60$) than the control group ($M = 2.31$, $SD = 0.70$). The difference was statistically significant, $t(68) = 7.11$, $p < .001$, with a large effect size ($d = 1.69$).
- For RQ1c, concerning Environmental Conservation, the experimental group achieved a higher mean score ($M = 4.18$, $SD = 0.63$) than the control group ($M = 2.87$, $SD = 0.81$). The difference was statistically significant, $t(68) = 7.62$, $p < .001$, with a large effect size ($d = 1.82$).
- For RQ1d, concerning Waste and Recycling, the experimental group obtained a higher mean score ($M = 3.39$, $SD = 0.58$) than the control group ($M = 2.15$, $SD = 0.74$). The difference was statistically significant, $t(68) = 7.82$, $p < .001$, with a large effect size ($d = 1.87$).
- At the overall level, the experimental group also achieved a higher total score ($M = 14.55$, $SD = 1.64$) than the control group ($M = 9.82$, $SD = 2.07$). The difference was statistically significant, $t(68) = 10.68$, $p < .001$, with a large effect size ($d = 2.55$).

Overall, the results show a consistent pattern across all four dimensions and the total score, with the experimental group outperforming the control group and showing large effect sizes in each comparison.

Results Related to RQ2: How Effective is Phenomenon-Based Environmental Learning in Enhancing Sustainability Values among Primary School Students?

To answer RQ2 and its two sub-questions, independent-samples t-tests were conducted to compare the posttest scores of the experimental and control groups on the Sustainability Values Scale. The analysis examined two dimensions: Environmental Sustainability Values and Social Sustainability Values, in addition to the total scale score. The results are presented in **Table 9**.

As shown in **Table 9**, the experimental group achieved higher posttest scores than the control group on both dimensions of the Sustainability Values Scale. All differences were statistically significant ($p < .001$), and the effect sizes were large across both dimensions and the total scale score.

- For RQ2a, concerning Environmental Sustainability Values, the experimental group achieved a higher mean score ($M = 43.77$, $SD = 3.89$) than the control group ($M = 34.26$, $SD = 5.18$). The difference was statistically significant, $t(68) = 7.84$, $p < .001$, with a large effect size ($d = 1.99$).
- For RQ2b, concerning Social Sustainability Values, the experimental group obtained a higher mean score ($M = 51.49$, $SD = 4.72$) than the control group ($M = 41.86$, $SD = 5.94$). The difference was statistically significant, $t(68) = 7.36$, $p < .001$, with a large effect size ($d = 1.81$).
- At the overall level, the experimental group achieved a higher total score on the Sustainability Values Scale ($M = 95.26$, $SD = 7.41$) than the control group ($M = 76.11$, $SD = 9.54$). The difference was statistically significant, $t(68) = 8.69$, $p < .001$, with a large effect size ($d = 2.10$).

The results show a consistent pattern across both dimensions and the total scale score, with the experimental group outperforming the control group and showing large effect sizes in all comparisons.

Results Related to RQ3: Is the Improvement in Environmental Concepts Associated with the Improvement in Sustainability Values among Primary School Students?

To answer RQ3, Pearson correlation analysis was conducted using gain scores, calculated as the posttest score minus the pretest score, for the Environmental Concepts Test and the Sustainability Values Scale. This analysis examined whether improvement in environmental concepts was

Table 10. Correlation between improvement in environmental concepts and improvement in sustainability values

Variables	Pearson's r	Strength of Relationship	p
Environmental Concepts Gain Score × Sustainability Values Gain Score	0.71	Strong Positive	< .001

associated with improvement in sustainability values. The results are presented in **Table 10**.

The results showed a statistically significant and strong positive relationship between improvement in environmental concepts and improvement in sustainability values, $r = .71$, $p < .001$. This indicates that students with greater improvement in environmental concepts tended to show greater improvement in sustainability values.

Overall, the results indicate a strong positive association between the two areas of improvement. Thus, higher gains in environmental concepts were associated with higher gains in sustainability values among the students in the study.

DISCUSSION

Environmental Concepts

The findings indicate that the Phenomenon-Based Environmental Learning Program was effective in enhancing students' environmental concepts across all dimensions of the Environmental Concepts Test. A possible explanation is that environmental concepts were introduced through meaningful environmental phenomena that students could observe and relate to in their everyday lives. Instead of learning concepts as isolated definitions, students explored questions connected to familiar situations, such as the growth of plants, the use of natural resources, environmental conservation, and waste management. This may have helped students connect abstract concepts with observable experiences, making environmental ideas easier to understand and apply.

The improvement in environmental concepts may also be attributed to the learning activities included in the program. Students actively participated in observation tasks, guided inquiry, classroom discussions, simple investigations, collaborative learning activities, and reflection. These activities encouraged them to examine environmental situations, exchange ideas, and construct explanations rather than rely on memorization. The program also organized environmental topics in connected contexts by linking living organisms, ecosystems, natural resources, environmental conservation, and waste management within authentic environmental situations. This organization may have supported students in developing a more integrated understanding of environmental issues instead of viewing each topic as a separate unit of knowledge.

Another factor that may explain the findings is the active role assigned to students throughout the learning process. Students were encouraged to ask questions, share observations, discuss explanations, and apply their understanding to new environmental situations. These opportunities for repeated inquiry and discussion were consistent with the principles of Phenomenon-Based Learning and may have been particularly appropriate for third-grade students, whose understanding is strengthened through direct observation, interaction, and discussion of familiar phenomena.

The present findings are consistent with previous research reviewed in this study. Kadarisman et al. (2023) found that phenomenon-based learning supported students' ecoliteracy through investigation of interactions between living things and the environment. This supports the present finding that learning through environmental phenomena can improve students' understanding of environmental issues. Similarly, Meechandee and Meekaew (2025) reported that phenomenon-based learning organized around real-world contexts improved students' engagement and learning, while Melesse et al. (2025) showed that contextualized instruction can support learning related to environmental concepts. These findings are in line with the present study, which found significant improvement across the four environmental concept dimensions. The present study extends this previous research by focusing on primary school students and by examining several environmental concept domains together within a quasi-experimental learning program.

Sustainability Values

The findings indicate that the Phenomenon-Based Environmental Learning Program was effective in enhancing both environmental and social sustainability values among primary school students. One possible explanation is that sustainability values were not presented as rules or recommendations to be memorized. Instead, students encountered authentic environmental situations, discussed them, and reflected on appropriate responses. Throughout the program, they explored phenomena related to water conservation, natural resource use, environmental protection, waste management, recycling, and environmental responsibility. These experiences may have helped students understand the reasons behind responsible environmental behavior rather than simply learning that such behaviors are desirable.

The improvement in environmental sustainability values may also be explained by the close connection between the learning activities and students' everyday experiences. Questions concerning water conservation, resource use, waste accumulation, and environmental protection encouraged students to reflect on their own actions and consider how their daily behaviors affect the environment. Presenting sustainability issues through familiar contexts may have increased the personal relevance of learning and supported the development of values that students could apply beyond the classroom.

The positive development of social sustainability values may be related to the collaborative nature of the program. Many learning activities required students to work together, exchange ideas, discuss observations, and participate in group problem-solving. Through these experiences, students practiced cooperation, shared responsibility, respectful communication, and participation in collective decision-

making. Such opportunities may have been particularly appropriate for primary school students, as learning through social interaction and shared experiences can support the development of positive attitudes and values alongside academic learning.

These findings are consistent with the literature reviewed in this study, which emphasizes the importance of meaningful learning experiences, participation, and responsibility in developing sustainability-related values. Heikkilä (2022) found that students engaged in phenomenon-based learning connected their learning experiences with sustainability-related concerns. This is consistent with the present finding that environmental phenomena can provide a context for developing sustainability values. Similarly, Husin et al. (2025) emphasized the role of environmental education in promoting responsibility toward environmental and social well-being, while Watt and Frydenberg (2025) reported that sustainability-focused educational experiences can support positive social outcomes. The present study extends these findings by showing that a Phenomenon-Based Environmental Learning Program can enhance both environmental and social sustainability values among primary school students within a school-based learning context.

Relationship Between Environmental Concepts and Sustainability Values

The findings suggest that improvements in environmental concepts and sustainability values developed together throughout the Phenomenon-Based Environmental Learning Program. One possible explanation is that the program did not treat conceptual understanding and sustainability values as separate learning outcomes. Instead, students explored environmental phenomena while discussing their implications for everyday behavior, environmental responsibility, and decision-making. As a result, understanding environmental concepts and developing sustainability values may have progressed simultaneously through the same learning experiences.

The nature of the environmental phenomena addressed during the program may also help explain this relationship. When students explored topics such as water conservation, waste management, recycling, and environmental protection, they were expected not only to understand the scientific ideas involved but also to consider appropriate responses to these environmental issues. Integrating conceptual learning with reflection on responsible actions may have strengthened the connection between what students understood and the values they developed. This integrated approach may have been particularly appropriate for primary school students, as linking knowledge with familiar experiences and everyday behaviors can make learning more meaningful.

Another possible explanation is that students are more likely to adopt sustainability-related values when they understand the reasons underlying environmentally responsible behavior. Learning how ecosystems function, why natural resources should be conserved, and how human activities affect the environment may provide a foundation for appreciating the importance of environmental responsibility. As students' understanding of environmental relationships became stronger, they may also have become more aware of their own role in protecting the environment and contributing positively to their communities.

The significant positive relationship found in the present study is also consistent with the literature reviewed in this study. Crase et al. (2024) argued that environmental understanding may not be sufficient unless learners also value environmental protection and sustainable practices. Similarly, Husin et al. (2025) and Bibi et al. (2026) emphasized the importance of connecting environmental understanding with responsibility and sustainable action. Guerrero and Sjöström (2025) also noted that environmental literacy involves more than factual knowledge and includes meaningful interpretation of environmental issues. These perspectives support the present finding that greater improvement in environmental concepts was associated with greater improvement in sustainability values. The present study extends this literature by providing empirical evidence of a strong positive relationship between the two outcomes among primary school students following a Phenomenon-Based Environmental Learning Program.

IMPLICATIONS OF THE FINDINGS

The findings of the present study have several implications for environmental and sustainability education at the primary school level:

- Environmental concepts may be developed more effectively when learning begins with observable environmental phenomena rather than isolated facts and definitions. Learning experiences connected to situations that students can recognize and discuss may support more meaningful conceptual understanding.
- The findings suggest that environmental concepts and sustainability values can be developed simultaneously through integrated learning experiences rather than being addressed as separate educational outcomes. Connecting conceptual learning with reflection on environmental responsibility may strengthen both forms of learning.
- Using environmental issues from students' immediate surroundings as starting points for learning may increase the relevance and meaningfulness of environmental education. Familiar contexts can encourage students to relate classroom learning to their own experiences and everyday decisions.
- The findings indicate that primary school students are capable of engaging with environmental and sustainability-related issues when learning activities are designed in ways that are appropriate to their developmental level and prior experiences.
- The study highlights that the educational value of Phenomenon-Based Environmental Learning extends beyond supporting conceptual understanding. The approach may also provide opportunities for students to connect environmental knowledge with responsible attitudes and behaviors.
- Classroom practices that encourage observation, questioning, discussion, and collaborative inquiry may

contribute to both the development of environmental concepts and the strengthening of sustainability values.

- The findings further suggest that environmental education can contribute to broader educational outcomes by helping students connect environmental understanding with responsible decision-making in everyday life.
- Overall, the findings support the use of Phenomenon-Based Environmental Learning as a framework for integrating environmental concepts and sustainability values within the same learning context, rather than addressing them independently.

IMPLICATIONS OF THE STUDY

This study demonstrates that Phenomenon-Based Environmental Learning (PBEL) enhances primary students' environmental concepts and sustainability values. The practical implications are as follows:

Classroom Practice

- Using Observable Phenomena: Teachers start lessons with local, observable phenomena-such as waste accumulation, water usage, or plant growth-rather than abstract definitions.
- Integrating Values with Concepts: Teachers embed value discussions directly into science lessons by asking students to evaluate the impact of daily habits on their immediate environment.
- Employing Collaborative Tasks: Teachers structure regular group tasks and discussions around local environmental problems to support cooperation and shared responsibility.

Teacher Professional Development

- Training on Phenomenon Selection: Professional development programs prepare teachers to select age-appropriate phenomena, formulate open-ended questions, and design inquiry activities.
- Developing Facilitation Skills: Training helps teachers guide student discussions, manage activity timing, and support group work during inquiry sessions.

Curriculum Design

- Structuring Units around Phenomena: Curriculum developers design science and social studies units around real-world environmental issues, including guides for hands-on observations and data collection.
- Connecting Content to the SDGs: Curriculum frameworks explicitly map local environmental topics to Sustainable Development Goal 4 (Quality Education) and Goal 13 (Climate Action).

Educational Policy and Support

- Providing Infrastructure Support: School administrators permit flexible scheduling and access to schoolyards or outdoor spaces required for observational tasks.
- Updating Evaluation Methods: Assessment policies incorporate performance-based tools that measure students' ability to analyze environmental situations and propose practical solutions.

Practical Considerations for Classroom Implementation

- The findings of the present study suggest that successful implementation of Phenomenon-Based Environmental Learning requires careful lesson planning and effective classroom management to support inquiry, collaborative discussion, and reflection within regular classroom instruction. Teachers may also need to adjust learning activities according to the available instructional time, class size, and students' learning needs while maintaining the core instructional sequence of the program. Such flexibility can help ensure active student participation and facilitate meaningful learning experiences without altering the educational objectives of the program.

LIMITATIONS

Several limitations should be considered when interpreting the findings of this study.

- The study employed a quasi-experimental design in which assignment to the experimental and control conditions was conducted at the school level rather than through random assignment of individual students. Although this approach helped maintain the normal organization of the participating schools and reduced interaction between the two groups during the intervention, the absence of random assignment may have allowed pre-existing differences between the schools to influence the findings.
- The study was conducted with a relatively small sample of third-grade students drawn from only two public primary schools in Egypt. Therefore, caution should be exercised when generalizing the findings to other grade levels, school types, geographical regions, or educational contexts.
- The intervention was implemented over an 11-week period, and students' environmental concepts and sustainability values were assessed immediately after its completion. Consequently, the findings reflect the short-term effects of the program, and no conclusions can be drawn regarding the long-term retention of environmental concepts or the stability of sustainability values. Future studies are encouraged to include follow-up assessments to examine the persistence of these outcomes over time.
- Environmental concepts were assessed using a researcher-developed test, whereas sustainability values were measured using a researcher-developed self-report scale. Although evidence of validity and reliability was established for both instruments, students' responses regarding sustainability values may have been influenced by social desirability or their perceptions of environmentally appropriate behavior. Future research may benefit from combining self-report measures with observational or qualitative evidence to provide a more

comprehensive assessment of sustainability-related values.

- The study relied primarily on quantitative data. Additional qualitative evidence, such as classroom observations, interviews, or students' reflections, could provide a deeper understanding of how phenomenon-based environmental learning supports the development of environmental concepts and sustainability values during the learning process.
- Finally, the intervention was implemented within the context of environmental education. Therefore, the findings should not be generalized to other subject areas without further investigation.

FUTURE RESEARCH

The findings of the present study suggest several directions for future research.

- Similar studies could be conducted with larger samples drawn from different regions and school settings to examine the consistency of the findings across contexts.
- Future research could investigate the effectiveness of phenomenon-based environmental learning at different educational stages, including upper primary, preparatory, and secondary education.
- Longitudinal studies may help examine whether improvements in environmental concepts and sustainability values are maintained over time after the intervention has ended.
- Future studies could explore additional outcomes associated with phenomenon-based environmental learning, such as environmental literacy, environmental responsibility, problem-solving skills, critical thinking, and student engagement.
- Future studies may adopt mixed-methods designs that combine quantitative measures with qualitative approaches, such as classroom observations, focus group interviews, or students' reflection journals, to provide a more comprehensive understanding of how students experience phenomenon-based environmental learning and construct environmental understanding through interaction with environmental phenomena.
- Comparative studies could examine phenomenon-based environmental learning alongside other instructional approaches used in environmental and sustainability education.
- Future research may also explore how digital technologies, virtual environments, or artificial intelligence tools can be integrated into phenomenon-based environmental learning to support students' engagement with environmental and sustainability issues.

CONCLUSION

The present study was conducted in response to the need for instructional approaches that help primary school students develop environmental understanding alongside sustainability-related values. Although environmental topics are commonly included in school curricula, transforming this content into meaningful learning experiences remains a challenge. The findings of this study suggest that organizing learning around environmental phenomena may offer one way of addressing this challenge.

Students who participated in the Phenomenon-Based Environmental Learning Program demonstrated higher levels of environmental concepts and sustainability values than their peers who received regular instruction. The study also found a positive relationship between improvements in environmental concepts and sustainability values, suggesting that understanding environmental issues and developing responsible orientations toward them may be more closely connected than they are often treated in classroom practice.

Beyond the specific results, the study highlights the importance of how environmental learning is organized. When environmental concepts were presented through questions, observations, discussions, and investigations linked to phenomena that students could recognize in their daily lives, learning moved beyond remembering information toward examining environmental situations and reflecting on possible responses to them. In this sense, environmental learning became connected not only to what students know, but also to how they think about environmental issues and their role within them.

The findings also draw attention to the potential of primary education as a context for sustainability learning. The results suggest that young learners can engage with environmental and sustainability-related issues when these issues are presented through experiences that are meaningful and appropriate to their developmental level. This may be particularly important given the growing expectation that schools contribute to preparing students to understand and respond to environmental challenges.

Within the limits of the present study, Phenomenon-Based Environmental Learning appears to be a useful approach for bringing together environmental concepts and sustainability values within the same learning process. Rather than treating environmental knowledge and sustainability values as separate educational outcomes, the findings suggest that both may be developed through learning experiences centered on meaningful environmental phenomena.

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REFERENCES

Ahrens, A., Dzerviniks, J., Skromule, I., Usca, S., Blazulioniene, S., Zascerinska, J., Kavolius, R., & Hognadottir, A. (2024). Sustainability values: A comprehensive framework for adult education. In *Society. Integration. Education. Proceedings of the International Scientific Conference* (Vol. 2, pp. 129–139). https://doi.org/10.17770/sie2024vol2.7799

Akkaş, E., & Eker, C. (2021). The effect of phenomenon-based learning approach on students' metacognitive awareness. *Educational Research and Reviews, 16*(5), 181–188. https://doi.org/10.5897/ERR2021.4139

Anisa, D., Kurniawan, D., & Munir, M. (2026). Phenomenon-based learning: A bibliometric analysis towards future-ready education. *Curricula: Journal of Curriculum Development, 5*(1), 69–84. https://doi.org/10.17509/curricula.v5i1.93737

Bibi, S., Nousheen, A., & Siddiquah, A. (2026). Effect of an environmental education course on prospective teachers' pro-environmental behavior: A study in education for sustainable development perspective. *International Journal of Sustainability in Higher Education, 27*(1), 220–236. https://doi.org/10.1108/IJSHE-09-2023-0422

Crase, L., Cooper, B., Burton, M., Baumgartner, L. J., & Ning, N. (2024). Adaptive management: Are important environmental concepts understood and valued by the public? *Australasian Journal of Environmental Management, 31*(3), 362–377. https://doi.org/10.1080/14486563.2024.2377774

Eker, C. (2026). Phenomenon-based learning in sustainable learning environments: Effects on autonomous learning and metacognitive awareness. *Sustainability, 18*(10), Article 5181. https://doi.org/10.3390/su18105181

Guerrero, G., & Sjöström, J. (2025). Critical scientific and environmental literacies: A systematic and critical review. *Studies in Science Education, 61*(1), 41–87. https://doi.org/10.1080/03057267.2024.2344988

Habash, R. (2022). Phenomenon-based learning for age 5.0 mindsets: Industry, society, and education. In *2022 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1910–1915). IEEE. https://doi.org/10.1109/EDUCON52537.2022.9766521

Heikkilä, E. (2022). *Sustainability through a phenomenon-based learning approach: A study of student reflections* [Master's thesis, University of Helsinki]. University of Helsinki Research Repository. University of Helsinki record.

Husin, A., Helmi, H., Nengsih, Y. K., & Rendana, M. (2025). Environmental education in schools: Sustainability and hope. *Discover Sustainability, 6*(1), Article 41. https://doi.org/10.1007/s43621-025-00837-2

Kadarisman, I., Pursitasari, I. D., & Jaenudin, D. (2023). Ecoliteracy of junior high school students through phenomenon-based learning on the interaction of living things with the environment. *Jurnal Penelitian Pendidikan IPA, 9*(11), 9075–9086. https://doi.org/10.29303/jppipa.v9i11.5180

Kahriman-Pamuk, D., & Borg, F. (2025). Sustainability, play and children's agency: A comparative study of the Swedish and Turkish preschool curricula. *European Early Childhood Education Research Journal, 33*(4), 659–675. https://doi.org/10.1080/1350293X.2024.2415948

Karakaş, G. (2026). Sustainability values orientation, minimalism, and happiness. *Sustainability Science*. Advance online publication. https://doi.org/10.1007/s11625-026-01812-0

Khatimah, K., Adnan, A., Mu'nisa, A., & Daud, F. (2026). The influence of phenomenon-based learning on creative thinking and collaboration skills. *Jurnal Eduscience, 13*(2), 531–548. https://doi.org/10.36987/jes.v13i2.9072

Khuana, T., Khuana, K., & Santiboon, T. T. (2025). Development of a phenomenon-based learning management instructional model for creative essential critical thinking skills in physical education students, Thailand National Sports University, Lampang Campus. *Journal of Education and Learning, 14*(6), 497–519. https://doi.org/10.5539/jel.v14n6p497

Klomim, K., Kuayngern, B., & Dhamatrakool, S. (2024). The development of the phenomena-based learning model accompanied by STEM for enhancing students' competency in science learning management. *Community and Social Development Journal, 25*(2), 195–211.

Kondrla, P. (2023). Sustainability values in religious education. *Journal of Education Culture and Society, 14*(1), 19–32. https://doi.org/10.15503/jecs2023.1.19.32

Kondrla, P., Ďurková, E., & Trstenský, F. (2024). Selected aspects in the perception of sustainability values among religious education teaching students. *Journal of Education Culture and Society, 15*(1), 73–84. https://doi.org/10.15503/jecs2024.1.73.84

Kristia, K., Kovács, S., & Erdey, L. (2024). Generation Z's appetite for traditional food: Unveiling the interplay of sustainability values as higher order construct and food influencers in Indonesia. *Discover Sustainability, 5*(1), Article 493. https://doi.org/10.1007/s43621-024-00714-4

Lardhi, J. S., & Ismail, A. F. (2026). Generative artificial intelligence for SDG 4: Enhancing sustainable quality learning. *Sustainability, 18*(5), Article 2498. https://doi.org/10.3390/su18052498

Lodico, M. G., Spaulding, D. T., & Voegtle, K. H. (2010). *Methods in educational research: From theory to practice* (2nd ed.). Jossey-Bass.

Mardikaningsih, R., & Essa, N. E. (2025). The compatibility of sustainability values and turnover intention in modern business organizations. *Bulletin of Science, Technology and Society, 4*(3), 79–90.

Marvi, K. M. H., Lodhi, I. S., Ahmed, Q., & Liaqat, H. (2025). A comprehensive analysis of phenomenon-based learning with scientific literacy in teaching and learning process for 21st century educational demands. *The Critical Review of Social Sciences Studies, 3*(4), 2852–2870.

Meechandee, S., & Meekaew, N. (2025). Integrating phenomenon-based learning and GIS to improve geo-literacy and student engagement: An action research approach. *Discover Education, 4*(1), Article 91. https://doi.org/10.1007/s44217-025-00468-9

Melesse, D., Menkir, S., Yemata, G., & Seifu, A. (2025). Effect of context-based instructional approach on students' science process skills acquisition in environmental concepts. *Education Inquiry*, 1–17.

Muhonen, T., & Sankila, K. (2026). *Inclusive phenomenon-based learning for 21st-century skills: Teacher's handbook*. Theseus. https://www.theseus.fi/handle/10024/927241

Muliana, M., Sari, S. M., & Sari, N. (2026). The utilization of Google Earth in improving elementary school students' understanding of environmental concepts. *Journal of Inclusive Primary Education Innovations, 1*(1), 11–18.

Naunthong, P., Nimsai, S., Punnakitikashem, P., & Kantabutra, S. (2026). Embedding sustainability values in logistics and supply chains: Linking organizational culture, practices, and performance. *Sustainability, 18*(11), Article 5496. https://doi.org/10.3390/su18115496

Oktobianti, A. A., Mu'nisa, A., Daud, F., & Azis, A. A. (2026). The influence of phenomenon-based learning on students' critical thinking and communication skills. *Jurnal Penelitian Pendidikan IPA, 12*(5), 146–154. https://doi.org/10.29303/jppipa.v12i5.14781

Paivandi, N., Shahhosseini, S., & Mansoori, S. (2024). Effectiveness of teaching environmental concepts through animism-based storytelling on children's environmental knowledge and environmental attitude. *Environmental Education and Sustainable Development, 11*(4), 25–39. https://doi.org/10.30473/ee.2023.66668.2598

Rezghi Shirsavar, H., & Salami, N. (2023). Prioritizing effective factors in training environmental concepts based on teaching models in higher education of Iran. *International Journal of Environmental Science and Technology, 20*(6), 5945–5956. https://doi.org/10.1007/s13762-023-04859-z

Saberi, M., & Nouri, N. (2025). Three-dimensional learning through phenomenon-based science education and its application via the collapsed container phenomenon. *Journal of Educational Studies in Physics, 2*(1), 73–91. https://doi.org/10.48310/esip.2025.18997.1012

Schaffar, B., & Wolff, L.-A. (2024). Phenomenon-based learning in Finland: A critical overview of its historical and philosophical roots. *Cogent Education, 11*(1), Article 2309733. https://doi.org/10.1080/2331186X.2024.2309733

Ualikhanova, B., Ormanova, G., Berdaliyev, D., Mussakhan, N., Anas, B., & Güdekli, E. (2024). Impact of phenomenon-based learning on high school physics education in Shymkent, Kazakhstan. *Qubahan Academic Journal, 4*(4), 225–236. https://doi.org/10.48161/qaj.v4n4a1203

Walker, K. I., & Nouri, N. (2025). Phenomenon-based learning and storylines in K–12 science education: A systematic review of current research, implementation, and future directions. *Frontiers in Education, 10*, Article 1648234. https://doi.org/10.3389/feduc.2025.1648234

Wallen, N. E., & Fraenkel, J. R. (2013). *Educational research: A guide to the process* (2nd ed.). Routledge.

Watt, B. A., & Frydenberg, E. (2025). Early childhood education for sustainability: Outcomes for social and emotional learning. *Australasian Journal of Early Childhood, 50*(2), 131–145. https://doi.org/10.1177/18369391241287939

Wolff, L.-A. (2023). Phenomenon-based learning. In S. O. Idowu, R. Schmidpeter, & N. Capaldi (Eds.), *Encyclopedia of sustainable management* (pp. 2577–2585). Springer International Publishing. https://doi.org/10.1007/978-3-030-02006-4_1172-1

Yanti, P. G., Suswandari, S., Amzat, I. H., Baadillah, I., Masrokhah, Y., & Karnawati, R. A. (2024). Phenomenon-based learning method to enhance students' skills in entrepreneurship course. *AIP Conference Proceedings, 3148*(1), Article 040048. https://doi.org/10.1063/5.0244157