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Collaborative lesson study: enhancing grade 2 students' explanations of scientific phenomena through outdoor STEM learning in the Context of Phuket Province

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Abstract This research aims to: 1)Investigate the competency in explaining scientific phenomena among second-grade students before participating in STEM learning outside the classroom in the context of Phuket province; 2) Develop students' competency in explaining scientific phenomena through STEM learning outside the classroom; 3) Develop STEM learning activities outside the classroom that enhance the competency in explaining scientific phenomena; and 4) Establish best practices for implementing STEM learning outside the classroom to promote students' competency in explaining scientific phenomena. The target group consists of 30 second-grade students from a school in Phuket province during the second semester of the 2024 academic year, selected through purposive sampling. Data collection and analysis were conducted throughout the teaching period, utilizing both qualitative and quantitative methods. Instruments included competency assessments, student behavior observations, learning activity sheets, and small group interviews. The data were analyzed using content analysis and statistical methods, presented in terms of mean, percentage, standard deviation, and student evidence. The findings indicate that before engaging in the learning activities, students had low competency levels in explaining scientific phenomena across all three indicators. In particular, the third indicator—evaluating the reasonableness of scientific explanations showed the lowest percentage at 11.5%. After participating in STEM learning outside the classroom, where students interacted with real-world contexts, their competency improved significantly. The first indicator constructing scientific explanations rose to 37.5%, the second indicator predicting scientific phenomena increased to 33%, and the third indicator—evaluating the reasonableness of scientific explanations improved to 37%. In conclusion, students' competency in explaining scientific phenomena significantly increased after the learning activities, with statistical significance at the 0.50 level. Students demonstrated the ability to apply scientific knowledge, reference evidence, and utilize scientific processes in their explanations. Explain natural or everyday phenomena systematically and logically, as well as formulate questions about natural phenomena and find answers using scientific concepts.

Keywords: explaining scientific phenomena, outdoor STEM learning, engineering design process

1. Introduction

Phuket is a province located in southern Thailand and is the largest island in the country; it is renowned for its tourism industry. The province features a blend of Thai and Chinese cultures, a historic old town with beautiful architecture, and a strong reliance on tourism for economic growth. Additionally, Phuket is known for its unique local cuisine, such as Khanom A-Pong and Oh-Aew. Provinces serve as ideal locations for outdoor STEM learning, providing opportunities for hands-on learning and environmental exploration. This learning approach bridges the gap between classroom education and the community, equipping students with essential competencies (Cobb & Yackel, 1996). This concept aligns with the objectives of Thailand's National Education Act of 1999, including amendments in 2002 and 2010 (Ministry of Education, 2010), which emphasize real-world learning experiences, critical thinking, problem solving, and the application of knowledge for problem prevention and resolution. Moreover, the Basic Education Core Curriculum (Revised 2017) in science education focuses on modernizing content to keep pace with advancements in scientific knowledge. It aims to develop students' problem-solving skills on the basis of reason, ethics, and information literacy while fostering an understanding of social relationships, change, and decision-making that considers personal, social, and environmental impacts. The curriculum encourages students to discover knowledge independently. Scientific explanation is a fundamental ability in science education and is essential for scientific literacy and competency development (De Jong, 2006). This involves three key components: 1) claims—starting an explanation or conclusion; 2) evidence—supporting the claim with data; and 3) reasoning—using scientific principles to justify the claim

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(McNeill & Krajcik, 2008). Students must apply knowledge, understanding, and analytical skills to construct explanations on the basis of evidence gathered through observation and experimentation (Ruiz-Primo et al., 2010). An assessment of students' scientific competencies, particularly their ability to explain scientific phenomena, revealed that second-grade students in the study group were at an early developmental stage. They could observe and state facts but struggled to construct explanations that logically linked evidence to conclusions (Organization for Economic Cooperation and Development, 2009). Additionally, students often incorporate personal emotions or subjective opinions into their explanations (Inoue, 2015; Janhom & Pornpisutimas, 2020). To help students adapt and solve problems in their social and environmental contexts, teaching strategies should prioritize student-centered learning on the basis of prior knowledge. Learning is a conceptual change process that reshapes students' understanding through diverse experiences, enabling them to integrate and differentiate concepts effectively (Khanserm, 2008; Elmas, & Geban, 2016). Children aged 7--11 years develop the ability to reason systematically, recognize abstract relationships, compare concepts, and explain their reasoning logically (Gilbert, 2006; Thima, Serirat, & Iamsa-ard, 2019). This study highlights the importance of outdoor STEM learning in enhancing students' ability to explain scientific phenomena, helping them connect knowledge with real-world experiences, and fostering critical thinking and reasoning skills essential for scientific understanding.

The significance and classroom situations presented above highlight the need for research to study and develop teachers' instructional practices to enhance students' competencies, particularly in the field of science. Therefore, this study aims to develop best practices for STEM education using local contexts to enhance students' specific competencies. This research focuses on students' ability to explain scientific phenomena and apply their knowledge in self-care, caring for others, their community, and the environment, ultimately fostering responsible citizenship at both the national and global levels.

1.1. Research objectives

1- To study the competence of second-grade students in explaining scientific phenomena before they participate in STEM learning outside the classroom in the context of Phuket Province.

2- To develop students' ability to explain scientific phenomena through instructional management via STEM learning outside the classroom in the context of Phuket Province.

3- To develop STEM learning management outside the classroom in the context of Phuket Province that enhances the competency of second-grade students in explaining scientific phenomena.

4- To identify best practices for managing STEM learning outside the classroom to increase second-grade students' competency in explaining scientific phenomena.

2. Methods and Materials

2.1. Research Framework

STEM education outside the classroom in the context of Phuket Province is a learning approach that emphasizes active student participation through hands-on experiences guided by the engineering design process. This process consists of six steps, from identifying problems to presenting outcomes. This learning model enhances students' analytical thinking, problem-solving, and research skills while increasing their ability to explain scientific phenomena—an essential competency in science, technology, engineering, and mathematics (STEM) education. Additionally, it enables teachers to design effective instructional strategies that promote meaningful learning in real-world contexts. The research framework is illustrated in Figure 1.

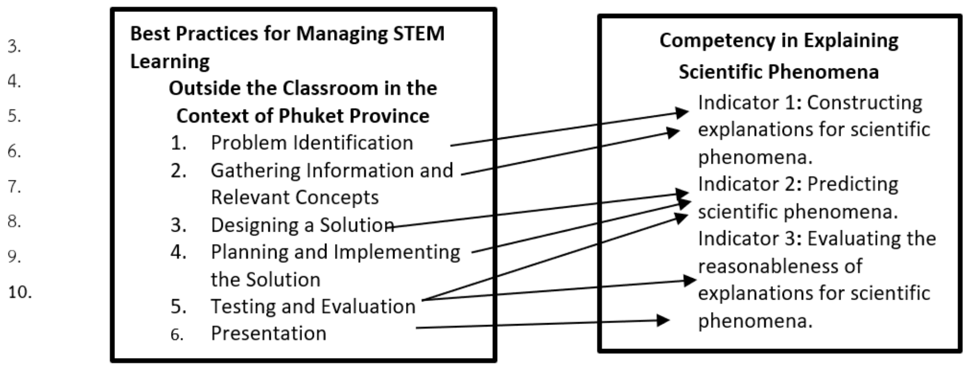


Figure 1 Research Framework.

2.2. Research methodology

This research uses the Classroom Action Research (CAR) methodology as a framework for study and development. The CAR cycle involves the teacher assuming the roles of both researcher and instructor. Each CAR cycle consists of four steps: 1. Planning (Plan): Investigate the problem or development approach, set research objectives, choose strategies or approaches to address the issue, and design activities and data collection methods. Action (Act): Implement the plan in the classroom and observe students' reactions to activities via research tools. Observation and Data Collection (Observe): Learning outcomes and student behavior are recorded, and the data are analyzed to determine the results and compare them to the set goals. Reflection and Revision (Reflect & Revise): Review the results from the activities, analyze what works and what needs improvement, and plan for the next cycle, as shown in Figure 2.

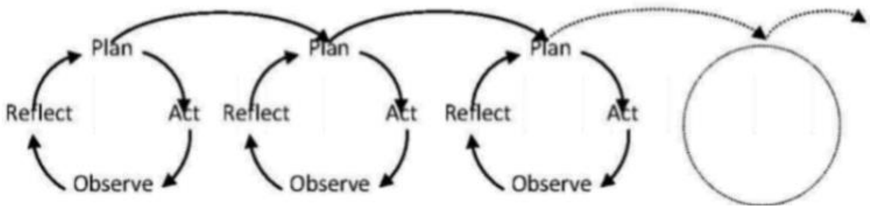


Figure 2 Steps of Classroom Action Research.
Source: Kemmis & McTaggart (1988).

This research consists of 5 CAR cycles: CAR 1: Preparation and review of prior knowledge; CAR 2: First learning management plan; CAR 3: Second learning management plan; CAR 4: Third learning management plan; CAR 5**:** Reflection on practice and performance assessment summary.

2.3. Scope of the Research

2.3.1. Research Participants

The research participants for this study consisted of 30 second-grade students from a large school in Phuket Province during the second semester of the 2024-2025 academic year. The participants were selected via purposive sampling with the following criteria:

1- The students are in second grade and are enrolled in the science subject for the second semester of the 2024-2025 academic year.

2- The students volunteered and were willing to participate in the research.

3- The students were those for whom the researcher served as the science instructor.

This study employs purposive sampling to select participants who can provide in-depth insights into the implementation of Outdoor STEM Education and its impact on fostering students' awareness of their local communities. Purposive sampling is appropriate for this research because it allows for the deliberate selection of individuals who meet specific criteria relevant to the study's objectives.

2.3.2. Content

In this research, STEM learning outside the classroom was implemented in the context of Phuket Province. The content covered science and technology, subject code W 12101, specifically in Chapter 1 for second-grade students, titled "Certain Properties of Materials." The content includes the properties of various types of materials, with a total teaching time of 14 hours.

2.3.3. Time Duration

The research was conducted with second-grade students during the second semester of the 2024-2025 academic year. It was scheduled for 2 hours of teaching per week over 7 weeks, totaling 14 hours of classroom instruction and 20 hours of self-directed learning between December 2024 and January 2025.

2.3.4. Location

The research was conducted at a school in Phuket Province under the jurisdiction of the Phuket Provincial Administration Organization. Research tools The research tools used in this study are divided into two sets as follows: 1. DevelopmentTools: 1.1 The development tool used in this research is the STEM learning management plan outside the classroom, which is based on the context of Phuket Province and consists of one unit of learning titled "Certain Properties of Materials." This includes three lesson plans with a total teaching time of 14 hours. The researcher provides detailed lesson plans in Table 1.

2.4. Research data collection tools:

2.4.1. Competency Measurement for Explaining Scientific Phenomena

On the topic "Certain Properties of Materials" (Prelesson and Postlesson). The total teaching time is 14 hours, with a focus on situations or phenomena occurring in the context of Phuket Province, along with open-ended questions.

2.4.2. STEM activity worksheetsheets

That emphasize the ability to explain scientific phenomena as part of the lesson plan for students during the learning activity The questions in these sheets align with the competency of explaining scientific phenomena and are used for collecting research data during the learning process, categorizing responses according to the indicator criteria.

Table 1 Details of lesson plans related to activities and time.

Learning Standards	Learning	STEM Lesson Plan	Time (Hours)
W 2.1 Understand the properties of matter, the composition of matter, the relationship between the properties of matter and the structure and bonding forces between particles, the principles and nature of changes in the states of matter, the formation of solutions, and the occurrence of chemical reactions.	2/1 Compare the water absorption properties of materials using empirical evidence and identify how the water absorption properties of materials can be applied in the creation of everyday objects.	1) Tie-dye fabric and Sino-Portuguese buildings	6
		2) The vibrant colors of rubber leaves are nontoxic and environmentally friendly	4
		3) Apoeng coconut milk made from natural colors.	4

2.5. Creation and evaluation of research tool quality

2.5.1. Steps in Creating STEM Learning Management Plans Outside the Classroom in the Context of Phuket Province: Topic: Properties of Materials

1- Study relevant documents and research on developing competencies to explain scientific phenomena using integrated STEM education (science, technology, engineering, and mathematics) as a framework for organizing content and activities appropriately.

2- The details of the content used in this research were studied from a second-grade science textbook according to the Basic Education Core Curriculum B.E. 2551 (Revised 2017).

3- The principles, concepts, and theories related to integrated STEM education should be studied to apply these principles in creating learning plans that involve science, technology, engineering design processes, and mathematics in the context of Phuket Province, with a focus on the following topic: Certain Properties of Materials. Three lesson plans with a total teaching time of 14 hours were created on the basis of the Basic Education Core Curriculum B.E. 2551 (Revised 2017).

4- The learning plans created by the researcher were reviewed by three experts for alignment with the learning objectives via the following scale: +1 (strongly agree that the plan aligns with the learning objectives), 0 (uncertain if the plan aligns with the learning objectives), and -1 (strongly disagree that the plan aligns with the learning objectives).

5- The researcher revises the learning plans on the basis of expert feedback.

6- The revised and appropriate learning plans are implemented with a target group similar to the research group.

2.5.2. Steps in Creating Competency to Explain Scientific Phenomena

1) Review documents, academic articles, and research studies related to problem-solving skills.

2) Develop a framework to measure competency in explaining scientific phenomena.

3) Create a competency measurement tool for explaining scientific phenomena, including questions based on given situations, along with competency criteria for explaining scientific phenomena.

4) Have the competency measurement tool and evaluation criteria reviewed by experts for accuracy.

5) The researcher revises the competency measurement tool and evaluation criteria on the basis of expert feedback.
6) Implement the revised competency measurement tool for explaining scientific phenomena with the target group.

2.6. Data collection

This study employed purposive sampling to select 30 second-grade students from a single class. These students were assessed via a pretest based on a competency assessment for explaining scientific phenomena, allowing for the categorization of responses and data presentation. Following the pretest, the students engaged in the learning process and were introduced to STEM-integrated lesson plans designed to promote understanding and active participation in alignment with the learning objectives. The researcher implemented the STEM-based lesson plans on the topic "Certain Properties of Materials" within the research group. The study followed the four steps of classroom action research—planning, acting, observing, and reflecting—over five action cycles. During the second semester of the 2024–2025 academic year, 30 second-grade students from a school in Phuket Province were included. The total teaching duration was 14 hours, with an additional 20 hours allocated for self-study.

2.7. Data analysis

This study employs a Classroom Action Research (CAR) approach, incorporating both qualitative and quantitative data collection methods. Accordingly, the data analysis consists of content analysis for qualitative data and statistical analysis for quantitative data. Quantitative data were analyzed using both descriptive and inferential statistical methods to ensure a comprehensive interpretation of the findings. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize participant characteristics and key study variables. This approach provides an overview of trends and distributions within the dataset, forming a solid basis for further analysis. To examine statistical significance in the relationships between key variables, t-tests were conducted, enabling comparisons between groups. These tests help determine whether observed differences are statistically meaningful within the study's context. In addition to quantitative analysis, content analysis was performed to analyze qualitative data through a thematic approach. This method facilitated the identification of key themes emerging from participants' responses, providing deeper insights into their experiences and perspectives.This mixed-methods analytical approach ensures a comprehensive understanding of the research findings by integrating both statistical evidence and qualitative insights. The researcher analyzed data obtained from various tools as follows:

The competency measurement tool for explaining scientific phenomena consists of open-ended questions based on the lesson content, with two sets (pretest and posttest). These tools cover all three indicators:

1. Creating explanations of scientific phenomena
2. Predicting scientific phenomena
3. Assessing the plausibility of explanations for scientific phenomena

Each set of assessment tools includes questions related to the topic "Certain Properties of Materials", designed to evaluate students' competencies both before and after the learning intervention. To ensure content validity, the tools were reviewed by three experts, and a pilot test was conducted with 10 students who shared similar characteristics with the research group. This process helped establish clear scoring criteria for students' responses, reflecting their ability to explain scientific phenomena effectively.For qualitative data analysis, measures were taken to ensure trustworthiness and consistency. Inter-rater reliabilitywas assessed by having multiple coders independently analyze a subset of the data. Their coding results were then compared to measure consistency. Cohen's kappa coefficient (or an alternative reliability measure, if applicable) was used to quantify the level of agreement between coders, with a high agreement level indicating reliability and reducing subjective bias in analysis. In cases where discrepancies between coders arose, discussion and consensus were used to refine the coding framework, ensuring a more standardized approach. This process strengthened the credibility and validity of the thematic analysis, ensuring that the findings accurately captured the participants' perspectives.

3. Research Results

From the qualitative and quantitative data analysis using the research tools collected before, during, and after the learning process, the researcher presents the findings:

3.1. Part 1

Results on the Competency to Explain the Scientific Phenomena of Second-Grade Students Before Participating in STEM-Based Learning outside the Classroom in the Phuket Context

The researcher used the competency measurement tool for explaining scientific phenomena to assess the students before the STEM-based learning intervention in the context of Phuket, covering all three indicators, as shown in Table 2.

Table 2 shows the results of the assessment of students' competencies in each indicator before learning management.

Indicators of Competency in Explaining Scientific Phenomena	Average Scores According to the Indicators
	Before the STEM Learning Intervention (40 scores)
1. Constructing Explanations of Scientific Phenomena	15.83
2. Predicting Scientific Phenomena	14.50
3. Evaluating the Reasonableness of Explanations of Scientific Phenomena	11.50

Table 2 shows that the students had the following competencies in explaining scientific phenomena. The first indicator measures students' ability to construct explanations of scientific phenomena before engaging in STEM experiences. The average score for this competency is 15.83.The second indicator assesses students' ability to predict scientific phenomena before participating in learning activities. With an average score of 14.50 and the third indicator evaluates students' ability to assess the reasonableness of scientific explanations before learning management with the lowest average score, 11.50.

3.2. Part 2

Results of the Development of the Scientific Phenomenon Explanation Competency of Grade 2 Students During the Use of the STEM-based Learning Approach Outside the Classroom in Phuket Context The results of the development of the scientific phenomenon explanation competency of Grade 2 students during the use of the STEM-based learning approach outside the classroom in the context of Phuket, which consists of 6 steps, is as follows: 1) Identifying the problem; 2) collecting information and ideas related to the problem; 3) designing methods to solve the problem; 4) planning and implementing the solution; 5) testing and evaluating the results; and 6) presenting the results.that the competency in explaining scientific phenomena in Activity 1, which involves tie-dyeing and the Sino-Portuguese buildings, showed that students had greater competence in explaining scientific phenomena after the lesson, as shown in Table 3.

Table 3 Results of the Evaluation of Scientific Phenomenon Explanation in Activity 1: Tie-Dyeing and Sino-Portuguese Architecture.

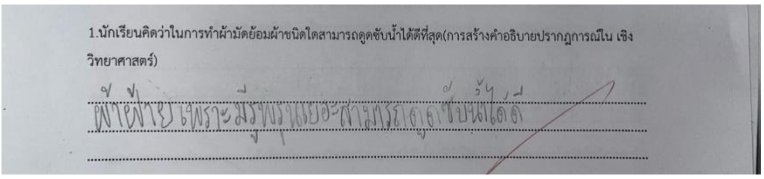
Average Scores According to Indicators of Scientific Phenomenon Explanation Competency			
Subcompetency:	1. Creating an explanation of scientific phenomena	2. Predicting scientific phenomena	3. Evaluating the reasonableness of explanations for scientific phenomena
Scores during the learning management	 31.88	28.22	30.66

Table 3 shows that in Activity 1, i.e., Tie-Dyeing and Sino-Portuguese Architecture, the students demonstrated the highest competency in explaining scientific phenomena through the indicator of creating an explanation of scientific phenomena, with an average score of 31.88. The next highest indicator was the reasonableness of explanations for scientific phenomena, with an average score of 30.66. The lowest indicator, 28.22, was used to predict scientific phenomena. An example of a student response showing the highest average score for the indicator of Creating an Explanation of Scientific phenpmena. The phenomena are presented in Table 4.

Table 4 Student Responses Demonstrating Competency in Indicator 1: Scientific Phenomenon Explanation Competency.

1. In your opinion, which type of fabric absorbs water the best for tie-dyeing? (Explain the phenomenon scientifically.)
Answer: Cotton, because it has many pores and can absorb water well.

The results of the development of scientific phenomenon explanation competency in Grade 2 students during use of a STEM-based learning approach outside the classroom, contextualized to Phuket Province, which consists of six steps: 1) Identifying the problem, 2) gathering data and relevant ideas related to the problem, 3) designing methods to solve the problem, 4) planning and implementing the solution, 5) testing and evaluating, and 6) presenting the results, show that students' ability to explain scientific phenomena during Activity 2 (Aponkati from Natural Dyes) was greater than that before the lesson, as shown in Table 5.

Table 5 Results of the Evaluation of Explaining Scientific Phenomena in Activity 2: Coconut Milk Dyeing from Natural Colors.

Average Scores According to Indicator of Competency in Explaining Scientific Phenomena			
Data Collection:	1. Creating Explanations of Scientific Phenomena	2. Predicting Scientific Phenomena	3. Considering the Reasonableness of the Explanation of Scientific Phenomena
Percentage During the Learning Process:	27.00	26.66	26.11

Table 5 shows that in Activity 2, "Coconut Milk Dyeing from Natural Colors," the students' ability to explain scientific phenomena was the highest indicator in terms of *creating explanations of scientific phenomena* at 27.00%. The next highest indicator was for *predicting scientific phenomena* at 26.66, whereas the lowest was *for explaining scientific phenomena* at 26.11%.

The example student answers with the highest indicator of *creating explanations of scientific phenomena* are shown in Table 6.

The results of developing the competency in explaining the scientific phenomena of Grade 2 students via the STEM-based outdoor learning approach in the context of Phuket, which includes six steps: 1) Identifying the problem, 2) Collecting relevant data and ideas, 3) Designing solutions, 4) Planning and implementing solutions, 5) Testing and evaluating, and 6) Presenting results, showed that in Activity 2, "Nontoxic, Environmentally Friendly Colors," students demonstrated greater competency in explaining scientific phenomena than they did before the lesson, as shown in Table 7.

Table 6 Student Answers Demonstrating Competency in Indicator 1: Explaining Scientific Phenomena.

5. In making Apoong dessert, flour is used as a key ingredient. When we mix flour with water, we find that the flour dissolves and blends uniformly with the water. Why does this happen? (Explain the phenomenon scientifically.)
Answer: Because flour contains certain compounds that are water-soluble. The more water there is, the better it dissolves.

Table 7 Results of the assessment of the explanations of scientific phenomena in Activity 3, "Nontoxic, eco-friendly colors".

Average Scores According to Indicator of Competency in Explaining Scientific Phenomena			
Data Collection	1. Creating Explanations of Scientific Phenomena	2. Predicting Scientific Phenomena	3. Considering the Reasonableness of Scientific Explanations
Percentage during Learning Process	30.22	27.44	27.88

Table 5 shows that the competency in explaining scientific phenomena in Activity 3, "Nontoxic, Eco-friendly Colors," the highest indicator, is “Creating Explanations of Scientific Phenomena,” accounting for 30.22. The next highest indicator is the reasonableness of scientific explanations, accounting for 27.88 of the variance. The lowest indicator is Predicting Scientific Phenomena, accounting for 27.44.

Examples of student responses with the highest percentage in creating explanations of scientific phenomena are shown below Table 8.

Table 8 Student responses demonstrating competency in Indicator 1: Competency in Explaining Scientific Phenomena.

3. Why do rubber tree leaves change color in different seasons? (Explain the phenomenon scientifically.)
Answer: This is due to temperature changes across seasons, which cause the leaves to shed and change color.

The learning process uses the STEM approach in out-of-classroom learning in the context of Phuket Province, with three lesson plans: 1) Lesson Plan 1: Tie-dye and Sino-Portuguese Architecture; 2) Lesson Plan 2: Apoong Coconut Milk from Natural Colors; and 3) Lesson Plan 3: Nontoxic, eco-friendly Colors. After the learning activities, the students demonstrated greater competency in explaining scientific phenomena than before the lessons. This was measured during the activities through activity sheets containing questions about the competencies in explaining scientific phenomena, all of which had three indicators.

3.3. Part 3

Results of the development of competency skills in explaining the scientific phenomena of second-grade students who participated in out-of-classroom STEM-based learning activities in Phuket Province.

On the basis of the study results, after engaging in out-of-classroom STEM-based learning, which consists of six steps: 1) identifying the problem, 2) collecting relevant information and ideas related to the problem, 3) designing problem-solving methods, 4) planning and implementing solutions, 5) testing and evaluating, and 6) presenting the results, the students' ability to explain scientific phenomena after participating in the activities was greater than that before the activities, as shown in Table 9 and Figure 3.

Table 9 Average Scores According to indicators of competence in explaining scientific phenomena before and after the learning process.

Indicators of Competency in Explaining Scientific Phenomena	Average Scores According to Indicators	
	Before	After
1. Creating Explanations of Scientific Phenomena	15.83	37.5
2. Predicting Scientific Phenomena	14.5	33.00
3. Considering the Reasonableness of Explanations of Scientific Phenomena	11.5	37.00

The data shown in the graph and the table above indicate that the indicator where students achieved the highest score was "Creating Explanations of Scientific Phenomena." Before learning, this indicator scored 15.83%, and after participating in the learning activities, it increased to 37.5%. The next indicator is "Considering the reasonableness of the explanation of scientific phenomena." Before learning, this score was 11.5%, and after participating in the activities, it increased to 37%. The last indicator was "Predicting Scientific Phenomena." Before learning, it scored 14.5%, and after participation, it improved to 33%. Notably, the development of the ability to explain scientific phenomena for each indicator before and after the learning process significantly improved.

From the evaluation scores of the indicators analyzing student responses in the activity sheets of each learning plan, it can be concluded that students have improved all three indicators of competency in explaining scientific phenomena. It is evident that in each activity within the STEM-based learning process outside the classroom, according to the Phuket context, the indicator with the highest average score is Indicator 1, creating explanations of scientific phenomena, and the indicator with the lowest average score is Indicator 2, predicting scientific phenomena.

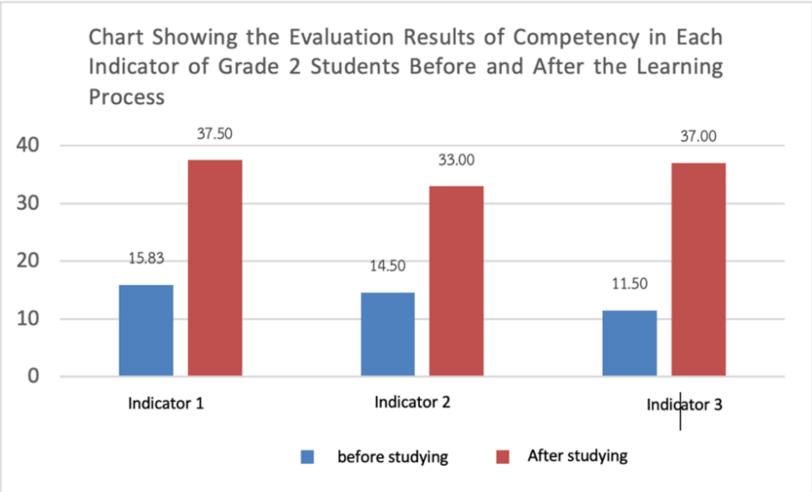


Figure 3 Average Scores of Achievement Analysis from the Development of the Scientific Phenomenon Explanation Competency of Grade 2 Students Who Received Learning According to the STEM Learning Approach Outside the Classroom in the Phuket Context, After vs. Before Learning.

The researcher used the competency measurement tool to grade and analyze the achievement results of the development of scientific phenomenon explanation skills for Grade 2 students who participated in the learning process according to the STEM approach outside the classroom in the Phuket context, comparing the postlearning results to the prelearning results, as shown in Table 10.

Table 10 Results of the analysis of learning outcomes from developing scientific explanation competencies in Grade 2 students who received STEM-based outdoor learning, contextually tailored to Phuket Province,Comparing postlearning with prelearning.

Score	Full Score	$\bar{x}$	S.D.	t	Sig.
Before learning	20	8.76	2.63	20.10*	0.00
After learning	20	16.93	1.20		

*Statistically significant at the .05 level.

From Table 10, the results of the study on developing Grade 2 students' scientific explanation competencies show that before they received STEM-based outdoor learning in the context of Phuket, the researcher collected data via a scientific explanation competency assessment tool. The prelearning average score was 8.76, with a standard deviation of 2.63. After the students received STEM-based outdoor learning in the context of Phuket, the average score was 16.93, with a standard deviation of 1.20. A t test was conducted to compare the differences, and the results revealed that the postlearning average score was significantly higher than the prelearning average score at a significance level of 0.00 (t = 20.10, sig = 0.00).

3.4. Part 4

Best practices in STEM-based outdoor learning. STEM-based outdoor learning in the context of Phuket Province is a teaching method that emphasizes students independently exploring knowledge with teachers acting as facilitators and providing guidance. This method encourages creativity and enables students to develop scientific explanation competencies. On the basis of the postteaching reflection on material properties, the analysis indicates that the STEM-based outdoor learning approach in Phuket Province should encourage students' scientific explanation competence. To create a learning environment conducive to exploration. Teachers should foster a friendly classroom atmosphere and allow students to express their opinions, leading to group discussions on the basis of data.

In each lesson plan, the researcher provides an example of only one learning plan. For example, in Learning Plan 1, titled "Tie-dyeing and Sino-Portuguese Buildings," the teacher begins by creating a friendly atmosphere in the classroom. The teacher discusses with the students about major tourist attractions in Phuket, asking them which places in the province they know that have architectural significance. The students respond, providing a variety of examples. The teacher then presents images of real locations for the students to observe. The students are given opportunities to express their opinions and ask questions about what they are learning. The learning environment is designed to be comfortable and conducive, promote participation and ensure that students feel safe in expressing their thoughts. The classroom teacher takes on the role of a facilitator and questioner, as illustrated in Figure 4.

Figure 4 Classroom learning environment.

The students gained confidence in expressing their opinions, and classroom learning became more engaging. The students were eager to answer the questions the teacher asked, especially in the second round, where they could discuss, express opinions, and draw conclusions regarding the creation of souvenir products related to tie-dyeing, as illustrated in Figure 5.

Figure 5 Learning environment in learning venues and the use of community classrooms.

The research results concluded that STEM-based out-of-classroom learning can support students in using scientific knowledge, referencing evidence, and applying scientific processes to explain phenomena occurring in nature or daily life in a systematic and logical manner. The three components of competence are as follows:

1- Use of Scientific Concepts: Students can link key scientific concepts to explain various phenomena.

2- Use of Empirical Evidence: Students can collect, analyze, and use reliable data or evidence to support explanations.

3- Use of Models and Scientific Reasoning: Students can use models or scientific concepts to demonstrate the mechanisms of phenomena.

Research has revealed that students develop behaviors indicating their competence in explaining scientific phenomena. These behaviors include asking questions about natural phenomena and seeking answers via scientific concepts, observing and recording data from experiments or real events, using data and empirical evidence to explain phenomena logically, demonstrating the ability to use models (e.g., diagrams, graphs, or equations) to explain phenomena, understanding the causes and effects of studied phenomena, and engaging in scientific discussions or arguments supported by evidence. Designing STEM-based outdoor learning activities to enhance scientific competence is grounded in the principle that real-world experiences are essential for fostering students' understanding of science. To achieve this, a set of STEM-based outdoor classroom activities was developed for Grade 2 students in Phuket, emphasizing the properties of materials through hands-on, engaging, and experiential learning. By integrating science, technology, engineering, and mathematics with real-world applications, these activities aimed to cultivate scientific inquiry, problem-solving skills, and a deeper connection to the environment and local culture.These activities were carefully structured into a comprehensive learning unit titled "Properties of Some Materials," which integrated STEM concepts with cultural and environmental elements unique to Phuket. The learning unit comprised three interconnected lesson plans, each aimed at helping young learners explore material science through creative and practical applications.The first lesson plan, "Tie-Dyeing and Sino-Portuguese Buildings," introduced students to the interaction of materials with different coloring substances. This activity connected the traditional craft of tie-dyeing with Phuket's historical Sino-Portuguese architecture, emphasizing the cultural significance of materials used in both fabric dyeing and building construction. By observing how different fabrics absorbed dyes in various ways, students explored the physical and chemical properties of materials. Through this hands-on experience, they not only developed their scientific inquiry skills but also gained a deeper appreciation for their local heritage and traditional craftsmanship. The second lesson plan, "Nontoxic, Eco-Friendly Rubber Leaf Colors," encouraged students to explore natural dyes derived from rubber leaves, a locally abundant resource. This activity introduced the concept of sustainability and environmentally friendly alternatives to synthetic dyes. By experimenting with color extraction and observing how plant pigments interact with different materials, students developed a deeper understanding of chemical composition, solubility, and material properties. This lesson also fostered environmental awareness, encouraging students to consider the benefits of using natural and eco-friendly materials over synthetic options. The final lesson plan, "Natural Color from Coconut Milk," focused on the use of coconut milk as a natural dyeing agent. Students learned how coconut milk interacts with other substances to produce different shades and color variations, reinforcing their knowledge of material transformation and chemical reactions. This activity allowed them to explore practical applications of natural resources in daily life, strengthening their connection to traditional practices and sustainable living. Through hands-on experiments, students enhanced their scientific reasoning and problem-solving skills while engaging with a commonly found natural material in their local community. Inconclusion, the STEM-based outdoor learning approach provided students with a dynamic and meaningful way to explore scientific concepts beyond the classroom. By integrating scientific inquiry, cultural heritage, and environmental sustainability, these activities not only enhanced students' understanding of material properties but also encouraged critical thinking, creativity, and ecological responsibility. The combination of hands-on experiments, real-world applications, and local relevance made learning more engaging and impactful. Ultimately, this approach helped young learners develop scientific competence while fostering a deeper appreciation for their surroundings and the sustainable use of natural resources. These activities developed scientific competence through six learning activity steps:

1.Identifying the problem.
2.Data and ideas related to the problem are collected.
3.Designing solutions.
4.Planning and implementing solutions.
5.Testing and evaluating the results.
6.Presenting results.

3.4.1. Learning Process Steps

Step 1: Identifying the Problem: Before the STEM-based out-of-classroom learning, the students were unable to identify the problem and what actions were required in the activity. This corresponds to Indicator 1, "Creating Scientific Explanations," with a percentage of 15.83%. After engaging in the learning activities, the students showed improved competence in explaining scientific phenomena, with Indicator 1 achieving 37%.

Step 2: Collecting Data and Ideas Related to the Problem: Before the learning intervention, students were unable to collect data or understand the concept of explaining scientific phenomena, corresponding to Indicator 2, "Predicting Scientific Phenomena," with a percentage of 14.5%. After engaging in the learning activities, the students demonstrated improved competence in explaining scientific phenomena, with Indicator 2 achieving 33%.

4. Discussion

The research findings indicate that developing skills in evidence collection and reasoning is a crucial component that students need to enhance through learning activities. Students should practice independently analyzing evidence from various types of data by interacting with external learning sources and integrating their findings into reflective classroom activities. Teachers play a key role in designing challenging learning experiences that encourage students to analyze situations, events, or phenomena critically. Students must use their judgment to evaluate evidence presented in activity worksheets and the data they collect independently during STEM activities. This process supports their decision-making in selecting materials for project creation or problem-solving strategies. For example, students may decide which dye to use for tie-dye fabric, choose the appropriate type of fat for a local dessert recipe, or design outdoor STEM learning activities. Such experiences enhance students' understanding of the role of evidence, helping them connect the information they gather with scientific concepts and applying it to answer key questions. This aligns with McNeil and Krajcik (2006), who reported that when teachers provide opportunities for students to engage with diverse forms of evidence and analyze it independently, they develop stronger evidence-based reasoning skills. They learn to distinguish reliable and relevant evidence that supports claims. Encouraging students to evaluate evidence on their own improves their understanding of its function and enhances their ability to construct scientific explanations effectively.

Therefore, this study suggests that to develop students’ ability to construct scientific explanations, particularly in the reasoning component, teachers should explicitly clarify the meaning of each element within a scientific explanation. Additionally, they should help students recognize the distinctions between these components through examples and regular practice in constructing scientific explanations on the basis of evidence and reasoning.

5. Conclusions

The findings of this study demonstrate that implementing a STEM-based outdoor learning approach in the context vvof Phuket significantly enhances second-grade students' competency in explaining scientific phenomena. The research results indicate a marked improvement in students' abilities across three key indicators: creating scientific explanations, predicting scientific phenomena, and evaluating the reasonableness of explanations. Before engaging in the learning activities, the students exhibited limited competency in explaining scientific phenomena, with the lowest scores observed in evaluating the reasonableness of explanations. However, after participating in STEM-based outdoor learning, students demonstrated substantial improvement in all three competency indicators, confirming the effectiveness of the approach. The most significant progress was observed in creating scientific explanations, which increased from 15.83% to 37.5%, while evaluating explanations improved from 11.5% to 37%, and predicting scientific phenomena increased from 14.5% to 33%. These findings highlight the importance of integrating real-world, hands-on STEM activities to support students in developing scientific reasoning, problem-solving skills, and evidence-based explanations. Furthermore, the structured six-step learning process—identifying problems, collecting information, designing solutions, planning and implementing, testing and evaluating, and presenting results—was instrumental in fostering deeper student engagement and enhancing their ability to analyze and interpret scientific phenomena. Activities such as tie-dyeing, exploring Sino-Portuguese architecture, and investigating natural dyes provided authentic learning experiences that helped students connect scientific concepts with real-life applications. In addition to this research, the results can present the best practices and implications for teaching and learning. This study concludes that the best practices for STEM-based outdoor learning include emphasizing the necessity of engaging students in inquiry-driven activities, where they actively observe, collect, and evaluate evidence to construct scientific explanations. The findings emphasize that engaging with nature through outdoor educational programs significantly enhances students' scientific reasoning and overall academic performance. Research indicates that such experiences cultivate critical thinking skills, environmental awareness, and personal growth. By participating in structured outdoor learning, students gain meaningful opportunities to bridge classroom knowledge with real-world experiences, reinforcing their understanding of scientific concepts. Therefore, educators should continue implementing hands-on, contextualized learning experiences to connect classroom science with real-world phenomena, fostering inquiry-based learning. Students learn most effectively when they explore diverse sources of evidence, analyze data, and critically evaluate their conclusions, which directly contributes to their scientific reasoning ability (Gerber et al., 2001). In particular, students’ discourse in science classrooms reflects their engagement in scientific practices and their socially constructed knowledge development (Cobb & Yackel, 1996). For example, Hogan et al. (2000) demonstrated how the complexity of students’ scientific reasoning varies in teacher-guided versus peer discussions. Integrating nature into the mainstream educational curriculum provides children, especially in urban environments, with regular opportunities to experience nature, helping to reduce disparities in access to natural spaces (Stevenson et al., 2020). Accordingly, a positive relationship is expected between students’ scientific reasoning ability and their engagement with nature-based learning. STEM educators should facilitate opportunities for reflection, peer discussion, and justification of scientific explanations, strengthening students' reasoning skills through scientific thinking and evidence-based argumentation. Moreover, integrating STEM learning in outdoor settings fosters curiosity, creativity, and problem-solving abilities among students. This research highlights the transformative impact of STEM-based outdoor learning in enhancing students' ability to explain scientific phenomena. The significant improvement in competency scores before and after the intervention confirms that active, evidence-based learning experiences are essential for deepening young learners’ scientific understanding (De Jong, 2006). Future research could explore the long-term effects of STEM-based outdoor learning on students' retention, problem-solving skills, and attitudes toward science. By integrating real-world experiences, hands-on inquiry, and structured reflection, STEM-based learning outside the classroom can play a crucial role in developing scientifically literate and reasoning-oriented students. This approach not only strengthens literacy in science, mathematics, technology, and ecology but also promotes social and environmental awareness through equitable access to nature. The findings also recommend that educators involved in teacher professional development provide ongoing training and a structured follow-up coaching system to support STEM teachers in schools. Establishing school networks with business enterprises is crucial for developing local learning resources that enhance STEM learning experiences.

6. Suggestions from the Research

6.1. Suggestions for Applying Research Results

The research findings indicate that developing the ability to explain scientific phenomena for Grade 2 students via the STEM-based out-of-classroom approach in the context of Phuket can improve their ability to explain scientific phenomena.

Therefore, educational institutions should encourage teachers to adopt this STEM teaching method to develop other competencies at various grade levels.

Before starting the learning activities, teachers should clarify the learning approach so that students fully understand the learning process. Students should be aware of their roles and responsibilities, allowing them the freedom to think within the scope of the content, whereas teachers should guide and provide close consultation.

Students should become familiar with STEM-based learning approaches. The first semester can be used to introduce the method, identifying any issues or shortcomings that arise, which can then be addressed to improve the learning approach clearly.

The STEM-based learning approach has time constraints. Teachers should be flexible with the time allocated for each step of the learning process, adjusting it as needed on the basis of the appropriateness of the activity.

6.2. Suggestions for Future Research

Future research should focus on the development of STEM education approaches with students from other grade levels, different subject areas, and various learning fields to study the outcomes and effects on students.

Future studies should also explore the implementation of STEM education approaches related to local wisdom or unique local products and how these approaches can contribute to solving problems within students' communities.

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Ethical considerations

This study adhered to ethical research standards, with all participants providing written consent by signing a consent form. The following ethical principles were upheld throughout the research process: Informed Consent: Participants were fully informed about the research objectives, procedures, potential risks, and their right to withdraw at any time without negative consequences. Written consent was obtained before participation. Confidentiality and anonymity: Personal information was kept confidential and used solely for research purposes. The data were anonymized to prevent any identifiable links to individual participants. Voluntary Participation: Participation was entirely voluntary. The participants had the right to refuse or withdraw from the study at any stage without penalty. Nonmaleficence: Every effort was made to minimize potential risks or discomfort. No harmful procedures or interventions were included in the study. Data Security: Collected data were securely stored and accessed only by authorized researchers. Data management followed relevant privacy and data protection regulations. Transparency and integrity: The research process and findings were reported transparently and honestly, ensuring accuracy and reliability in data presentation and interpretation. These measures ensured that the participants’ rights, safety, and well-being were protected throughout the study.

Conflict of Interest

The authors declare no conflicts of interest.

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References

Chai-Chana, N., et al. (2021). The impact of context-based learning combined with questioning techniques on the ability to explain scientific phenomena of grade 4 students. *Graduate Research Journal, 2*(2), July–December.

Chan-Hom, C., et al. (2020). An exploration of the ability to create scientific explanations about the digestive system.

Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspectives in the context of developmental research. *Educational Psychologist, 31*(3–4), 175–190.

De Jong, O. (2006). Context-based chemical education: How to improve it. *Chemical Education International, 8*(1), 1–7.

Elmas, R., & Geban, Ö. (2016). The effect of context-based chemistry instruction on 9th-grade students’ understanding of cleaning agents topic and their attitude toward environment. *Education and Science, 41*(185), 33–50. https://doi.org/10.15390/EB.2016.5502

Falzon, D., & Conrad, E. (2024). Designing primary school grounds for nature-based learning: A review of the evidence. *Journal of Outdoor and Environmental Education, 27*, 437–468.

Gerber, B. L., Cavallo, A. M. L., & Marek, E. A. (2001). Relationships among informal learning environments, teaching procedures, and scientific reasoning ability. *International Journal of Science Education, 23*(5), 535–549.

Gilbert, J. K. (2006). On the nature of context in chemical education. *International Journal of Science Education, 28*(9), 957–976.

Inoue, N. (2015). *Beyond actions: Psychology of action research for mindful educational improvement*. New York, NY: Peter Lang.

Kemmis, S., & McTaggart, R. (1988). *The action research planner* (3rd ed.). Geelong: Deakin University Press.

Labutdee, P., et al. (2024). The development of scientific literacy through STEM education combined with social issues related to science, focusing on the greenhouse effect for grade 6 students. *Western University Research Journal: Humanities and Social Sciences, 10*(1), 219–230.

McNeill, K. L., & Krajcik, J. (2006). Supporting students' construction of scientific explanation through generic versus context-specific written scaffolds. *The Journal of the Learning Sciences, 15*(2), 153–191.

McNeill, K. L., & Krajcik, J. (2006, April). Supporting students' constructions of scientific explanation through generic versus context-specific written scaffolds. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Ministry of Education. (2017). *Indicators and content of the core curriculum in the science learning area* (Revised ed.). Bangkok: Agricultural Cooperative Federation of Thailand Press.

Organization for Economic Co-operation and Development. (2009). *PISA 2009 assessment framework: Key competencies in reading, mathematics and science*. http://www.oecd.org

Ruiz-Primo, M. A., Li, M., Tsai, S. P., & Schneider, J. (2010). Testing one premise of scientific inquiry in science classroom: Examining students' scientific explanation and student learning. *Journal of Research in Science Teaching, 47*(5), 583–608.

Saengprasert, B. (2021). The study of learning achievement and scientific explanation of the topic of photosynthesis among grade 5 students using the 7E inquiry-based learning model combined with scientific explanation strategies. *Education Journal, 23*(4), 240–251.

Stevenson, K. T., Moore, R., Cosco, N., Floyd, M. F., Sullivan, W., Brink, L., Gerstein, D., Jordan, C., & Zapalatosch, J. (2020). A national research agenda supporting green schoolyard development and equitable access to nature. *Elementa: Science of the Anthropocene, 8*(1), 10. https://doi.org/10.1525/elementa.419

Thima, P., et al. (2013). The development of a teaching model based on Piaget's theory of cognitive development to develop critical thinking skills for grade 6 students. *Academic Journal of Phetchaburi Rajabhat University, 9*(1), 204–210.