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Using Context-Based Learning to Enhance Thai Grade 6 Student Scientific Reasoning Abilities

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Abstract

The purpose of this study was to examine the impact of a context-based learning (CBL) management plan on the scientific reasoning abilities of Grade 6 students in Thailand. The participants consisted of 13 students from a public school in the northeastern region. The research instruments included a two-tier multiple-choice test to assess scientific reasoning abilities and an observation checklist to monitor reasoning behavior during the learning sessions. Data were analyzed using descriptive statistics, including frequency, percentage, and relative development scores, to measure student improvement. The results indicated a significant increase in students' scientific reasoning abilities, with an average score improvement from 13.14% before the intervention to 56.00% after. The majority of students demonstrated moderate to high improvement in their reasoning skills. This study contributes to the growing body of evidence supporting the effectiveness of context-based learning in enhancing critical thinking and problem-solving skills in science education.

Keywords: context-based learning, science education, scientific reasoning ability

1. Introduction

As the demand for 21st Century Skills represents a new approach to education, students are now expected to keep up with rapid changes and respond to various situations happening in the world (Dhir, 2020; Zamora & Zamora, 2022). Therefore, learning must align with the rapidly changing global context and aim to foster lifelong learning. In other words, simply having knowledge is not sufficient for survival in the 21st century without skills (Gümüş, 2022; Tan et al., 2017). The Programme for International Student Assessment (PISA) in terms of science assessment emphasizes the application of scientific knowledge in everyday life, taking a broader view of science to recognize various types of knowledge necessary for participation in contemporary society (OECD, 2023). Contextually, Thai government also require that education must be based on the principle that every student can learn and develop, and that students are the most important aspect (The Ministry of Education, 2008). The educational process must promote students' natural development to their fullest potential. Thus, learning management must adapt and broaden the way science is taught, encouraging reasoning that helps students understand knowledge holistically. Promoting learning in diverse contexts fosters reasoning skills better than teaching within a single context (Bezci & Sungur, 2021). Teachers must create learning experiences in varied contexts suited to students' abilities, allowing them to apply scientific knowledge to real-life situations.

To fulfill student development in the current situation, scientific reasoning ability as one of crucial thinking skills in 21st century learning is present in science education class as the capacity to think logically and systematically about scientific concepts and processes (Osborne, 2013; Shavlik et al., 2022). The skill would enable learners to analyze evidence, draw conclusions, and apply knowledge to solve problems (Luo et al., 2021). However, it is challenging to form such an ability as several cognitive tasks could involve. In detail, learners should identify the whole picture of the matters. This can be systematic when data, evidence, and facts are connected to what they conclude (Krell et al., 2022). Therefore, leaners should also be able to explain the relationship between conclusions and supporting evidence. This also includes evaluating and verifying information using evidence and reasoning to support answers, conclusions from investigations, or scientific explanations. These elements are crucial in helping students move beyond memorization, equipping them with the skills to approach scientific questions methodically and think critically about the world around them.

However, both instructors and students in science courses may find it challenging to develop their scientific reasoning skills. As previously mentioned, students must perform various cognitive tasks such as analyzing data, connecting information, and drawing conclusions to enhance their scientific reasoning skills. Additionally, they must comprehend various related concepts such as wind movement, sea level, earth crusts, among others, to achieve these skills. This is not likely to be completed by the traditional lecture-based instruction criticized as one of the main problems in Thai education, as evidenced by the results of domestic (National Institute of Educational Testing Service, 2022) and international assessments (OECD, 2022). Instead, an instructional method should provide learners opportunities to learn in an active and meaningful learning environment.

To deal with the situation, context-based learning is introduced into this study to promote the connection of classroom knowledge to real-life situations. According to Blokdyk (2021), this approach creates real-life scenarios for students and encourages scientific reasoning and understanding of knowledge holistically. Context-based learning engages students in activities and practical experiences that allow them to apply their knowledge in everyday life (Rose, 2012; Stolk et al., 2016). Students learn scientific reasoning relevant to specific situations by following four steps: 1) Setting the context—introducing the learning, stimulating curiosity, and connecting prior knowledge with new learning experiences, 2) Practical engagement—students research and explore the context, 3) Learning and sharing—students analyze, interpret, and conclude based on their understanding of the context, and 4) Applying and developing—students apply their knowledge in other real-world contexts (Blokdyk, 2021; Deveci & Karteri, 2022; Pilot et al., 2016; Rose, 2012; Stolk et al., 2016).

Empirical evidence supporting context-based learning (CBL) in science education has demonstrated its potential to generate positive outcomes in the classroom. Scholars have consistently found that CBL enhances students' engagement, understanding, and application of scientific concepts. For example, Avargil and Piorko (2022) found that high school students' understanding of molecular representations improved significantly when taught using a context-based multi-model chemistry learning approach. Baydere (2021) demonstrated that a context-based approach incorporating prediction-observation-explanation activities positively influenced students' conceptual understanding of the states of matter, heat, and temperature. Similarly, Deveci and Karteri (2022) revealed that using context-based learning supported by environmental measurement devices in science teacher education led to better integration of scientific concepts and practical skills. Furthermore, Ngozi (2021) highlighted that CBL effectively enhanced science process skills acquisition in chemistry among secondary school students, showing that the approach promotes deeper learning and application of scientific knowledge. These studies collectively affirm the effectiveness of CBL in fostering scientific reasoning and learning achievement.

The development of the current study hinged on the potential of CBL to enhance science learning achievements and scientific reasoning skills in science classrooms. Additionally, previous studies have encouraged the exploration of this method in various areas of science education. We acknowledge the importance of scientific reasoning ability, but to our knowledge, no CBL studies have addressed it yet. Therefore, we utilized the principle of context-based learning to create a learning environment for grade 6 students in the Thai educational context, aiming to enhance their scientific reasoning skills while they study topics related to global phenomena and natural disasters. The purpose of the study was to examine the effect of context-based learning (CBL) learning management plan on Thai grade 6 students' scientific reasoning abilities.

2. Methodology

2.1 Research Design

The study utilized a one-group action research design. The study applied CBL as a principle to learning activities within a learning management plan. We implemented it for grade 6 students as they learned about the concept of world disasters in their science education class. We assessed their scientific reasoning abilities using a behavior observation form and a scientific reasoning abilities assessment form.

2.2 Participants

The participants were 13 Grade 6 students from a public school in the northeastern region of Thailand. The school is situated in a local area where certain primary schools in remote areas provide education from Grade 1 to Grade 9. The selected school is part of a group of nine schools in the area. The cluster sampling method was used to select one school from this group, and the 13 participants were students enrolled in that selected school.

2.3 Research Instruments

2.3.1 CBL Learning Management Plan

The context-based learning management plan was designed and applied in the Science subject (code: W16101) of grade 6 students on the topic of world phenomena and natural disasters. A total of 9 learning management plans were developed, covering a duration of 9 hours. These plans included: 1) a learning plan on the occurrence of monsoons, 2) a learning plan on the greenhouse effect and global warming, and 3-9) learning plans on natural disasters (landslides, floods, earthquakes, coastal erosion, and tsunamis). The learning activities in each plan were designed using the principles of context-based learning (CBL). Therefore, students were asked to connect the scientific concepts to real-world situations, analyze relevant issues in their local environment, and apply their knowledge to solve problems related to natural disasters. For example, At the beginning of the class, the teacher introduced the topic of floods by projecting a series of news headlines and photographs depicting recent flooding events in the students' region. This initial hook sparked curiosity and set the stage for a context-based approach, where students would connect scientific concepts to real-world conditions they could directly relate to. After a brief class discussion of their personal experiences—such as recalling a neighbor's basement flood or a nearby river that overflowed—students were encouraged to share their initial ideas about what causes floods and what factors make certain areas more vulnerable than others.

Then, the teacher guided the students to identify key scientific concepts related to flooding, such as rainfall patterns, soil composition, and land use changes. To deepen their understanding, the class examined detailed maps of their community, scrutinizing how the shape of the land, the presence or absence of vegetation, and the types of structures built near waterways might influence flood patterns. Working in small groups, students analyzed soil samples (brought in beforehand or illustrated through images) and discussed how erosion during rainy seasons can contribute to flooding. They also considered the impact of deforestation—how removing trees and shrubs can reduce the ground's ability to absorb water, thereby increasing run-off and raising flood risks.

Throughout the lesson, the teacher integrated opportunities for inquiry-based discussion. Students brainstormed the relationship between climate patterns, changing land use over time, and the frequency of local floods. They drew diagrams to visualize water flow over various terrains, exploring how different ground materials (e.g., clay vs. sandy soil) and man-made structures (such as roads and buildings) affect drainage and water retention. As they worked, the teacher circulated among the groups, asking probing questions—"What might happen if we replant trees along the riverbank?" or "How do you think paving over this area changes where the water goes?"—to prompt deeper reasoning and encourage students to refine their ideas with evidence-based thinking.

In the application phase, students shifted from analysis to solution design. Using their observations and research, each group proposed a flood mitigation strategy tailored to their community. Some groups sketched models for improved drainage systems, incorporating features like permeable paving or strategically placed retention ponds. Others advocated for reforestation projects, illustrating how planting native species could stabilize the soil and slow water run-off. Still others considered public policy measures, such as zoning regulations that limit construction in flood-prone areas. Each proposal was accompanied by a short, evidence-based rationale that connected the recommended measure to underlying scientific principles.

Finally, at the end of the lesson, the teacher administered a brief assessment to measure students' scientific reasoning abilities. This assessment included short-response questions requiring students to explain the connection between landscape features and flood risk, interpret data on rainfall patterns, and justify why certain mitigation strategies would be effective based on scientific principles. As a culminating activity, the teacher asked students to reflect on their learning process, identifying how the combination of local context, collaborative discussions, and expert feedback enhanced their understanding. This reflection not only reinforced their newly developed reasoning skills but also empowered them to apply these insights to real-world environmental challenges they may encounter in the future.

The plan was evaluated by 5 reviewers who were scholars in education management and professional teachers and found at an appropriate level.

2.3.2 Scientific Reasoning Abilities Assessment Form

The scientific reasoning ability test was designed as a two-tier multiple-choice test to assess both knowledge and reasoning ability. The test consists of an Answer tier for evaluating factual knowledge and a Reason tier that asks students to explain the reasoning behind their answers. Students' ability to draw conclusions, identify evidence, and explain the relationship between them were the assessment focus. The question content covers topics of monsoons, the greenhouse effect, global warming, and natural disasters. The test underwent content validity evaluation, with IOC scores between 0.60 and 1.00, and reliability testing using Cronbach's alpha, resulting in a reliability score of 0.900. Difficulty and discrimination indices confirmed the suitability of all test items for use.

2.3.3 Behavior Observation Form

The behavior observation form for reasoning is structured as a checklist, focusing on key indicators of scientific reasoning. The content validity of the questions was assessed by determining the Index of Item-Objective Congruence (IOC) between the behavioral indicators and the questions, using a set consistency criterion. The results showed that the IOC ranged from 0.80 to 1.00, exceeding the required threshold. The checklist evaluates behaviors such as 1) the ability to identify conclusions, 2) the ability to identify data, evidence, and facts, 3) the ability to explain the relationship between conclusions and evidence, and 4) the ability to evaluate and verify, using evidence and reasoning to support answers, conclusions from investigations, or scientific explanations.

2.4 Data Collection and Data Analysis

The data collection process includes an orientation stage where research explains the objectives of the learning activities and administered a pre-test on scientific reasoning ability, which lasted for one hour. Following this, the researcher implemented nine context-based learning activity plans on world phenomena and natural disasters for Grade 6 students, totaling nine hours during regular school hours. Throughout each session, the researcher used a behavior observation checklist to monitor students’ reasoning abilities. After each lesson, the observation data were collected, summarized, and used to reflect on and improve the next learning plan. Once all sessions were completed, a post-test on scientific reasoning ability was administered, also lasting one hour. For data analysis, descriptive statistics such as frequency and percentage were employed, and students' progress in learning achievement was measured using relative development scores. This process provided insights into both the effectiveness of the learning activities and the development of students' scientific reasoning skills.

3. Results

3.1 Participants’ Behaviors of Scientific Reasoning Throughout the Study

Table 1. Participants’ scientific reasoning behaviors

Components of Scientific reasoning abilities	**Observation 1**	**Observation 2**	**Observation 3**	**Average**
1. Capable of identifying conclusions	61.54	57.69	69.23	62.82
2. Capable of recognizing relevant data, evidence, and facts	53.85	65.38	65.38	61.54
3. Able to explain the connection between conclusions and supporting evidence	61.54	66.67	53.85	60.68
4. Able to evaluate and validate findings, using evidence and reasoning to justify answers, conclusions from investigations, or scientific explanations	69.23	64.10	58.97	64.10
Average	61.54	63.46	61.86	62.29

The study results (Table 1) show that students' average scientific reasoning skill was highest in Component 4 ($\bar{x}$ = 64.10), which involves checking and evaluating answers, conclusions from investigations, or scientific explanations using evidence and reasoning. The lowest average scientific reasoning ability was in Component 3 ($\bar{x}$ = 60.68), which involves explaining the relationship between conclusions and evidence. Overall, students demonstrated excellent reasoning behavior based on observations during the learning process.

3.2 The Impact of CBL Learning Management Plan on Participants’ Scientific Reasoning Abilities

Table 2. Participants' scientific reasoning abilities before after the use of the plan

Scientific reasoning abilities	**N**	**Full mark**	$\bar{x}$	**S.D**
Pre-test	13	7	0.92	1.12
Post-test	13	7	3.92	1.19

According to Table 2, the scientific reasoning abilities of students before the context-based learning management plan showed an overall average score of 0.92 (S.D = 1.12) out of a total score of 7, equivalent to 13.14%. After the learning sessions, the students' average score increased to 3.92 (S.D = 1.19) out of a total score of 7, equivalent to 56.00%, which was considered a passing expected level.

3.3 Relative Development Scores or the Percentage of Individual Learning Achievement Improvement

Table 3.

Students	Pretest	Posttest	%	Relative development level
1	3	5	50.00	Average
2	2	6	80.00	Very high
3	1	3	33.33	Average
4	0	2	28.57	Average
5	0	3	42.86	Average
6	3	4	25.00	Low
7	0	3	42.86	Average
8	1	5	66.67	High
9	1	5	66.67	High
10	0	5	71.43	High
11	0	3	42.86	Average
12	0	3	42.86	Average
13	1	4	50.00	Average
Average			49.47	Average

According to Table 3, the study investigates how much 13 sixth graders improved their learning through context-based learning. The improvement was measured by their relative development scores, and the results showed that the students improved on average at a moderate level, with an average relative development score of 49.47. Based on relative development scores, we found that the majority of students (8 students, or 61.54%) showed moderate improvement in their scientific reasoning abilities. Following this, 3 students (23.08%) showed high improvement in scientific reasoning abilities, while 1 student (7.69%) showed very high improvement, and 1 student (7.69%) exhibited low improvement in scientific reasoning abilities.

4. Discussion

The findings of this study could be interpreted to indicate the effectiveness of the context-based learning (CBL) management plan in improving scientific reasoning abilities among Grade 6 students. The results demonstrate that CBL can significantly enhance students' cognitive abilities, specifically in the area of scientific reasoning. Before the implementation of the CBL learning management plan, students showed low performance, with an average score of 13.14%, indicating limited scientific reasoning abilities. However, after the CBL intervention, their scores increased substantially to an average of 56.00%, representing a clear improvement and demonstrating the potential of CBL in addressing the challenges of traditional lecture-based instruction, which has been criticized for its limitations in fostering critical thinking and problem-solving skills in Thai education.

These findings are consistent with previous research on the efficacy of context-based learning in science education. As highlighted by Avargil and Piorko (2022), CBL approaches enhance students' understanding of complex scientific concepts by allowing them to engage in multi-model learning scenarios. Similarly, Baydere (2021) found that using a CBL framework helped students grasp fundamental science concepts such as states of matter and temperature, which aligns with the improved scientific reasoning abilities observed in our study. Furthermore, Deveci and Karteri (2022) and Ngozi (2021) supported the idea that CBL encourages active engagement and practical application of scientific knowledge, leading to better cognitive development and skills acquisition. The results of this study corroborate these findings, as students demonstrated substantial progress in their ability to evaluate and verify information using evidence and reasoning (Component 4) and a general improvement across other components of scientific reasoning.

The notable development in the component 4, which asks students to check and evaluate their answers using evidence and reasoning ($\underline{x}$ = 64.10), shows that the CBL method worked especially well at getting students to think more deeply and solve problems. This is an essential skill for 21st-century learners, as it aligns with the need for individuals to navigate complex, real-world challenges by applying scientific knowledge and critical thinking. However, the lower performance in Component 3, which involves explaining the relationship between conclusions and evidence ($\bar{x}$ = 60.68), indicates that students may require further support in understanding how to link evidence to conclusions effectively. This may suggest the need for refining the instructional methods within the CBL approach to place greater emphasis on guiding students through the process of connecting data to conclusions.

The analysis of relative development scores also provides an interesting perspective on individual student progress. Most students (61.54%) demonstrated moderate improvement in their scientific reasoning abilities, which points to the overall success of the CBL approach in fostering cognitive growth in science education. The fact that a smaller group of students (23.08%) showed high improvement, with one student (7.69%) achieving very high improvement, suggests that CBL can cater to different learning paces and abilities, offering differentiated opportunities for student development. However, the observation that one student (7.69%) showed low improvement indicates that CBL, while generally effective, may not fully address the needs of all learners, particularly those who may require more personalized support or alternative instructional strategies.

The improvement observed in students' scientific reasoning abilities can be explained by the principles of context-based learning (CBL), which emphasizes the connection between classroom knowledge and real-life situations. CBL promotes active engagement with content, encouraging students to apply scientific concepts to practical scenarios (Pilot et al., 2016; Stolk et al., 2016). This aligns with the development of higher-order thinking skills, such as evaluating and verifying information, as seen in the students' improvement in Component 4 (evaluating answers and conclusions using evidence and reasoning). By placing students in realistic contexts where they must analyze evidence and make informed decisions, CBL fosters deeper understanding and critical thinking (Blokdyk, 2021; Rose, 2012). The structured process of CBL—setting the context, engaging in practical activities, analyzing data, and applying knowledge—directly supports the development of scientific reasoning (Deveci & Karteri, 2022). This method likely contributed to the students' ability to connect scientific concepts to real-world phenomena, leading to the overall improvement in their reasoning skills and problem-solving abilities observed in the study.

5. Conclusion

In summary, this study demonstrates that the CBL learning management plan is a valuable tool in improving scientific reasoning abilities in Grade 6 students, particularly in promoting higher-order thinking and problem-solving skills. The findings align with existing literature on the benefits of CBL in science education and highlight its potential to foster meaningful learning experiences that go beyond rote memorization. Nevertheless, future research could explore how to further enhance students' ability to link evidence to conclusions and consider how to adapt CBL approaches to better support students who may not benefit as much from this instructional method. Additionally, it would be beneficial to examine the long-term impact of CBL on students' scientific reasoning and whether these improvements translate into broader academic success and real-world application.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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