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Implementation of the STEAM Approach in Understanding the Phenomenon of Global Warming: A Case Study of Making a Mini Greenhouse to Improve Students' Scientific Thinking Skills

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ABSTRACT
Global warming represents a critical environmental issue exacerbated by increasing greenhouse gas emissions, necessitating mitigation strategies that incorporate effective environmental education at the elementary school level. Although STEAM-based learning has demonstrated efficacy, further investigation is required into its practical implementation—such as through the construction of a mini greenhouse—to enhance students' scientific thinking skills. This study seeks to describe the implementation of the STEAM approach integrated with the Project-Based Learning (PjBL) model in improving students' scientific thinking skills. A descriptive qualitative method was employed. Data were collected through direct observation of students' experimental activities, process documentation, and interviews designed to capture student understanding. The approach assessed students' competencies in observation, inquiry, and inference during the construction of a mini greenhouse. The findings indicate that implementing STEAM through the five phases of PjBL significantly enhanced key indicators of scientific thinking, including observation, inference, prediction, and scientific communication. Students successfully drew connections between temperature phenomena observed in the mini greenhouse and global warming on Earth. Primary enabling factors included student enthusiasm and the accessibility of materials, whereas constraints involved limited time and inadequate measuring instruments. The implications of this study suggest that the STEAM approach aligns with the Independent Curriculum and reinforces the Pancasila Student Profile by cultivating critical, creative, and collaborative thinking. Future research should broaden the scope of subject areas and extend the observation period to evaluate the impact on environmental literacy more comprehensively.
Keywords: STEAM; global warming; scientific thinking skills; elementary school

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INTRODUCTION

One of the world's major environmental problems is global warming, caused by increasing concentrations of greenhouse gases in the atmosphere due to human activities such as the use of fossil fuels, motor vehicles, and industrial activities. The sun's heat is trapped in the atmosphere, causing the Earth's temperature to continue to rise, which has an impact on climate change, ecosystem damage, and disruption to human life (Prabawati et al., 2021). Therefore, sustained efforts are needed to mitigate the impacts of global warming by increasing environmental awareness and education from an early age. In education, global warming must be understood not only as a theoretical concept but also contextually so that students can relate it to their daily lives. Meaningful learning can encourage students to care more about the environment and help them understand the phenomenon more deeply. However, in practice, learning is often teacher-centered and lacks direct experience. As a result, students' scientific thinking skills are not well developed.

The STEAM (Science, Technology, Engineering, Art, and Mathematics) approach is one that can be used to address this issue. This approach enables integrated, contextualized learning that is oriented toward solving real-world problems. With this method, students will not only understand concepts but also actively engage in the learning process through exploration and experimentation (Khumaira et al., 2024). In this way, learning becomes more interesting and is able to improve students' scientific thinking skills.

Observing, questioning, analyzing, and drawing conclusions based on information are essential components of scientific thinking skills. These abilities are closely related to scientific literacy and the critical thinking skills students need to address various problems in everyday life (Cahyani & Nugroho, 2024). Therefore, well-planned learning can help students develop systematic, logical, and evidence-based thinking skills. To provide a more concrete learning experience, the STEAM approach can be used in conjunction with a project-based learning model. Project activities provide students with the opportunity to enhance their creativity and critical thinking skills, as well as engage directly in the learning process and collaborate in groups (Ramadhan, 2023). By incorporating the STEAM approach into a project-based learning model in science, students can be motivated to learn actively, collaboratively, and reflectively through direct involvement in projects, and help students improve their ability to think scientifically and enhance their understanding of concepts contextually. This approach also helps students improve their ability to observe, analyze, test, and draw conclusions (Sumampouw et al., 2025). One method that can be used is to create a mini greenhouse to simulate the greenhouse effect. Using a mini greenhouse as a teaching aid, students can observe the phenomenon of increasing temperature in an enclosed space as an illustration of the greenhouse effect. Through this activity, students can make observations, record experimental results, analyze data, and draw systematic, evidence-based conclusions (Marpaung et al., 2024). Therefore, learning becomes more contextual, interactive, and meaningful.

Based on the above description, it can be concluded that implementing a project-based STEAM approach by creating a mini greenhouse can improve students' scientific thinking skills. Therefore, this study aims to examine how the application of the STEAM approaches to understanding the phenomenon of global warming through the creation of a mini

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greenhouse reactor and how it impacts elementary school students' scientific thinking skills.

LITERATURE REVIEW

The STEAM approach is a learning method that is currently gaining popularity. Many researchers have conducted studies on STEAM learning, and the results show that this method improves student responses. STEAM combines disciplines such as science, technology, engineering, art, and mathematics. The benefits of the STEAM approach are helping students become problem-solvers, creative, innovative, independent, logical thinkers, understand technology, and are able to connect STEAM concepts to the world of work (Makkasau et al., 2023). The implementation of the STEAM approach is expected to be able to become a means of introducing global issues to students, especially elementary school students.

The issue of global warming is a global issue and has received special attention from the United Nations. It is listed as an indicator to be achieved in the Sustainable Development Goals (SDGs) program, specifically addressing climate change. Global warming is a crucial issue and impacts many aspects of life, including the environment, the economy, and public health. The increase in Earth's average temperature is causing more frequent and severe natural disasters. The worst consequence of global warming is the extinction of species, which leads to changes in ecosystems and disrupts the ecological balance, significantly impacting human life (Kurniawan et al., 2024).

The first research conducted by Makkasau et al (2023) showed that the implementation of the STEAM approach was able to improve elementary school students' learning outcomes in science subjects, with a completion percentage reaching 91% compared to the initial percentage of 45.5% of the total number of students. On the other hand Nurfajariyah and Kusumawati (2023) shows that implementing the STEAM approach in elementary school students presents several challenges, ranging from teacher training, access to facilities and infrastructure, to efficient time management.

The conceptual framework for making a mini greenhouse in this study integrates the following aspects: (1) science, understanding the working principles and concept of the greenhouse effect; (2) technology, using scissors, cutters, squares, or glue guns as tools to shape components; (3) engineering, designing a sturdy miniature building structure; (4) art, designing the appearance of the miniature to make it look attractive; and (5) mathematics, measuring and calculating the things needed to make the miniature.

Based on the problem identification, this research aims to answer the following questions:

1. How can implementing the STEAM approach improve elementary school students' scientific thinking skills?
2. Can building a mini greenhouse improve elementary school students' understanding?

METHOD

This study uses a descriptive qualitative approach to provide an in-depth overview of global warming learning through a project-based STEAM approach. This approach was chosen because of the problems discussed in the introduction, namely students' lack of contextual understanding of global warming events and the need for learning that can develop scientific thinking skills in a concrete and meaningful way.

By using a descriptive qualitative approach, researchers can thoroughly investigate how students gain understanding through hands-on experience. As a simulation of the greenhouse effect, this study embodies the experience by creating a mini greenhouse. This activity aligns with the STEAM-based learning model, which emphasizes the integration of various disciplines in a real-world context, thereby increasing students' active engagement and enhancing their scientific thinking skills. This is in line with research showing that the STEAM project-based learning model is effective in improving students' scientific thinking skills and increasing their active engagement in the learning process. This method teaches students to carry out scientific actions such as observing, asking questions, analyzing, and drawing conclusions in a systematic manner based on experimental results. This process aligns with the objectives of science learning, which emphasizes hands-on scientific experiences. Furthermore, it has been shown that implementing STEAM in project-based learning can significantly improve students' critical thinking skills and their science process skills (Suryaningsih & Nisa, 2021).

In this study, three data collection methods were used: observation, interviews, and documentation. Observation was used to directly observe student activities during the learning process, particularly during the mini greenhouse experiment. Interviews were conducted to determine how well students understood and reflected on the experience of learning. Meanwhile, documentation collected evidence, such as photos of activities and notes on the implementation process. These three methods were combined to increase data validity through triangulation, so that the data obtained could demonstrate the development of students' scientific thinking skills. In STEAM-based educational research, observation, interview, and documentation techniques have also been widely used to uncover the learning process (Pertiwi et al., 2025).

Therefore, the approach used in this study is in line with the focus of the study in the introduction, namely how the project-based STEAM approach can make learning contextual, meaningful, and focused on developing students' scientific thinking skills to understand the phenomenon of global warming.

FINDINGS

The implementation of the STEAM approach combines components of science, technology, engineering, art and mathematics which are able to produce real and meaningful learning experiences for student participants, especially at the elementary school level (Rahmadhani, 2025). In its use, the STEAM approach integrates student-centered constructivism theory and includes several activities or projects (Rahma & Isralidin, 2022). The implementation of STEAM is carried out starting from the planning

stage, implementation stage and evaluation of activities, the planning stage is carried out as an initial preparation to compile activities to be carried out and ensure that activities run according to plan. The planning stage must be carried out carefully so that the implementation stage is in accordance with the flow of activities. The implementation stage is the realization stage of the planning that has been previously made. The implementation stage is the key to collecting data. The final stage is the evaluation activity. At this stage researchers can measure the achievement and effectiveness of the activities that have been carried out. Evaluation can be feedback and measure the level of student understanding.

The experimental class implemented a Project-Based Learning (PjBL) model to enhance students' understanding of the concept of global warming. The learning process was divided into several structured stages, from the introduction to the presentation of the results.

In the first stage of group formation and commitment, the teacher directs students to form small groups of 4-5 people. This stage can build students' soft skills, as each group develops collaborative work rules that emphasize mutual respect and active participation. Clearly assigning roles to each student ensures that project responsibilities are shared equitably, a key foundation of project-based learning.

In the second stage of the collaborative discussion, students are given reinforcement of concepts related to global warming and the greenhouse effect. In this stage, the science aspect emerges as the teacher explains these natural phenomena and provides opportunities for students to express their opinions. This discussion aims not only to transfer information but also to hone students' communication and empathy skills by cultivating the habit of listening attentively to each other's opinions.

In the third phase of project planning, students begin to explore the realm of engineering and problem-solving. They are asked to design a mini greenhouse reactor. This process involves intensive discussion regarding the work steps and the selection of appropriate materials. The teacher's role in this stage is to act as a guide, assisting students in making joint decisions, ensuring the design is logical and implementable.

In the fourth stage of the project, students realized their designs by building a mini greenhouse reactor in groups. During the construction and observation process, simple mathematics and technology aspects were applied, with students periodically observing changes in temperature or conditions inside the device. Students were trained to be meticulous in recording their observations, which is part of the scientific method for collecting authentic data from their projects.

Finally, in the fifth stage of the presentation, each group presents their experimental results to the class. This stage serves as a means of evaluating and communicating learning outcomes. The teacher provides feedback on students' work to reinforce this. Through this activity, students can summarize their learning outcomes regarding the importance of protecting the environment to reduce the impact of global warming.

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Overall, the PjBL syntax for creating this mini greenhouse reactor has been shown to engage students in scientific thinking. This aligns with previous research showing that project-based learning has a positive impact on elementary school students' problem-solving skills and understanding of environmental concepts.

DISCUSSION

1. Scientific Thinking Skills of Elementary School Students During the Learning Process

a. Observation

Based on views Azzahra & Putri (2025), In conducting scientific activities, it is crucial to use a STEAM approach, which will make scientific research more effective. Students engage in hands-on practice to understand the process of global warming using transparent plastic. This observation process is crucial in supporting students, as it provides a direct example, demonstrating the greenhouse effect using plastic.

b. Inference

Azzahra & Putri (2025) stated that by using the STEAM approach, students will better understand what they are learning. The hot plastic walls make students aware of the greenhouse effect, which ultimately leads them to learn that this phenomenon also occurs on planet Earth. The hot conditions in the mini greenhouse provide a very clear picture of the daily human activities that contribute to global warming.

c. Predictions

Predictions are made to make students understand future events Widyastika et al (2025) Problem-solving is easily understood using the STEAM approach and is fun for students. Some students realized that global warming has serious impacts on the Earth, such as melting polar ice caps, ecosystem extinction, and extreme temperatures. Students were able to make these predictions after observing a very hot mini greenhouse and describing it on Earth.

d. Scientific Communication

According to Azzahra & Putri (2025) Presentation activities became more enjoyable for students because they immediately understood the concepts through practical exercises using a mini greenhouse. The mini greenhouse designs the students created and presented to the class encouraged students to be more active, especially in discussing the issue of global warming and its impact on the earth. Students used the terms greenhouse effect and global warming during their presentations. Students' soft skills, communication skills, and increased active participation are enhanced by the highly effective STEAM approach (Widyastika et al., 2025).

These four indicators of scientific thinking skills are fully integrated within the STEAM approach framework. Students are more creative, more engaged, and eager to collaborate with their classmates thanks to the effective STEAM approach (Azzahra & Putri, 2025). In the students' analysis of global warming, they gained understanding through

seeing the mini greenhouse. Students' practical activities and scientific learning became more effective using the STEAM approach.

2. Supporting and Inhibiting Factors in STEAM Implementation in Students

a. Supporting Factors

1) High Student Enthusiasm

Learning through mini greenhouse projects will be enjoyable for students because they are considered creative and fun. Students in the classroom really enjoy everyday games, so the STEAM approach fosters their enthusiasm. Educators will be able to focus better if students understand that project-based learning makes them understand easily and enjoyably.

2) Ease of Obtaining Mini Greenhouse Materials

Utilizing unused or locally available materials will make it easier for students to practice their mini greenhouses. Providing readily available equipment significantly aids the learning process.

b. Inhibiting Factors

1) Limited Learning Time

Project-based learning will take longer than regular learning. Rahmadhani (2025) acknowledged that a common obstacle is implementing STEAM learning within a limited timeframe, which makes it less than optimal. Time-consuming mini-greenhouse activities are ineffective if only briefly studied, and students lack understanding of the purpose of the practice.

2) Differences in Student Abilities and Availability of Measuring Instruments

Group activities tend to favor only one or two groups with a majority of students. Inadequate facilities in a poor school will significantly impact practical implementation. Educators must be able to implement alternatives if the learning process doesn't go as planned.

3. Pancasila The Relevance of STEAM to the Independent Curriculum and the Pancasila Learning Profile

The STEAM approach used in the environmental project shows a strong correlation with the learning approach in the Merdeka Curriculum. This is evident in the learning activities that focus not only on theory but also on how students view their surroundings. The learning process becomes more significant because students are encouraged to actively participate, experiment, and discover knowledge for themselves through real-world activities. The Pancasila Student Profile is also supported by the implementation of STEAM. Students are trained to think critically by observing and understanding the processes that occur during the activities. When students create works with materials found in their environment, they also become more creative. Conversely, students work collaboratively during the activities, as they talk to one another and help complete group assignments. Furthermore, the role of the teacher in these activities is crucial. The teacher not only explains the material but also assists and guides students throughout the learning

process. By giving them the opportunity to experiment and discover for themselves, students become more active and confident in their learning. Therefore, it can be concluded that the STEAM approach based on this environmental project is not only aligned with the Merdeka Curriculum but can also help build student character that aligns with the Pancasila Student Profile (Rahayu & Budiwan, 2025)

CONCLUSION

The application of STEAM (Science, Technology, Engineering, Arts, and Mathematics) has been shown to significantly improve students' scientific thinking skills. Through stages of investigation and experimentation, students are able to formulate hypotheses and conduct systematic observations. A mini greenhouse project integrating these five disciplines allows students not only to understand theory but also to practice scientific steps. The engineering and aesthetic design processes involved in constructing the mini greenhouse structure also foster more critical and creative problem-solving skills.

Given that this study focused on scientific thinking skills, further research could be developed to measure its impact on environmental literacy or student creativity, using a broader range of subjects and longer observation periods. It is recommended to include more reflective discussion sessions at the end of each STEAM stage to strengthen students' metacognitive skills in understanding the rationale for a scientific approach.

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