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Best-Practice Project: STEAM and Cooperative Learning to Improve Understanding of Global Warming

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Abstract

STEAM and Cooperative learning have become effective approaches in enhancing students' understanding of scientific concepts, including global warming.This study aims to evaluate the effectiveness of applying STEAM and Cooperative methods in enhancing the understanding of global warming among 10th-grade IKM 11 students at MAN 1 Kota Bekasi.The methods used include creating infographics based on Canva, simple experiments modeling the greenhouse effect, and assessments based on Google Form.The research results show that the average student assessment scores increased from 64.03 (previous material) to 85.89 (after the implementation of the method).Additionally, the analysis of data distribution shows a more uniform improvement in understanding among students.Factors supporting the success of this method include project-based learning, technology integration, and active interaction in group discussions.Thus, the implementation of the STEAM and Cooperative learning models not only improves student learning outcomes but also contributes to the Sustainable Development Goals (SDGs) Goal 4 (Quality Education) and Goal 13 (Climate Action), as well as supporting Indonesia's Golden Vision 2045 in building superior and competitive human resources.

Keywords: cooperative learning, global warming, learning evaluation, project-based learning, STEAM

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INTRODUCTION

STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning is an interdisciplinary approach that integrates various fields of knowledge to enhance students' creativity, problem-solving, and critical thinking skills (Chang et al., 2023; (Gu et al., 202).This approach is highly relevant to the subject of Physics (Ozkan & Umdu Topsakal, 2020), especially at

the high school level (Sekolah Menengah Atas). At this level, specifically in phase E of grade X, the learning outcomes include understanding global warming as part of natural phenomena (Yilmaz & Can, 2020). In the context of learning about global warming, the STEAM approach allows students to understand this complex phenomenon through various exploratory methods (Kersanszki et al., 2024), such as experiments, simulations, and technology-based data visualization (Thacker, 2024). Thus, learning is not only theoretical but also provides direct experiences that enrich students' conceptual understanding of climate change issues and their impacts.

In line with the STEAM approach, cooperative learning also becomes an effective strategy in enhancing student engagement (Maričić & Lavicza, 2024). This model emphasizes cooperation in small groups, where students discuss and solve problems collaboratively (Lin et al., 2021). Project-based learning, such as creating infographics, can build students' conceptual understanding (Jaleniauskiene & Kasperiuniene, 2024). Through this strategy, students not only memorize theory but also apply their understanding in real situations and develop better communication and teamwork skills (Şanal & Torun, 2024).

Understanding global warming has become one of the crucial aspects in science education, particularly Physics, because it relates to climate change issues, the greenhouse effect, and various contributing factors (Ahima, 2020). The lack of understanding regarding this topic can lead to low environmental awareness among students, which ultimately contributes to a lack of concern for climate change mitigation (Jurek et al., 2022; Feldbacher et al., 2023).Therefore, the combination of STEAM and cooperative learning methods is expected to enhance students' active engagement and deepen their understanding of this issue.

The improvement of understanding about global warming has strong relevance to the vision of Golden Indonesia 2045 (Tresnawati et al., 2023), which targets emission reduction and prevention of global warming.Furthermore, the implementation of this learning also supports the achievement of Indonesia's Sustainable Development Goals (SDGs) (Basuki et al., 2022), particularly Goal 4 (Quality Education) and Goal 13 (Climate Action).

Quality education can be seen from the use of innovative teaching methods (Zhou, 2022). Innovative learning methods can ensure more relevant, practice-based education access and equip students with the skills needed in the future (Dula & Porter, 2021; Rasa, 2024). Meanwhile, increasing awareness and understanding of global warming contribute to efforts in climate change mitigation, which is a primary focus of sustainable development.Thus, the implementation of best practices in STEAM-based and cooperative learning not only impacts the improvement of student learning outcomes but also aligns with national and global efforts to create a generation that is more aware and responsible towards the environment.

METHOD

This best practice was implemented from February 4, 2025, to February 25, 2025, in the X IKM 11 class at MAN 1 Kota Bekasi, which consists of 36 students.Learning uses the STEAM and Cooperative approach, which emphasizes group work and the integration of various

disciplines.Students are divided into heterogeneous groups, where each group is led by a leader who has the highest Physics assessment results and good leadership skills.

Sample Research

The sample in this study consists of all students from class X IKM 11 MAN 1 Kota Bekasi, totaling 36 individuals.The selection of this sample was based on the consideration that the class had completed the previous material on Renewable Energy, allowing for a comparison of assessment results before and after the implementation of this teaching method.This class also has a considerable level of heterogeneity in terms of academic ability, which can provide an overview of how the STEAM and Cooperative learning methods impact students with varying levels of understanding.

Data Collection

Data collection is carried out using several techniques, namely:

Observation

The teacher observes the students' activity in group discussions, experiments, and infographic creation.Student participation in presentations and class discussions is also observed to measure their engagement in learning.

Documentation

All the infographic designs created by the students were collected and analyzed based on creativity, accuracy of information, and relevance to the concept of global warming.The results of the students' experiments on modeling the greenhouse effect were also documented for analysis.

Assessment

Assessment is conducted after the implementation of the method.This assessment is given in the form of digital-based questions through Google Form, which contains questions about the concept of global warming.The form of assessment used refers to the assessment and evaluation guidelines, which are in the form of multiple-choice and complex multiple-choice questions.

Data Processing

The data that has been collected was analyzed using a quantitative approach.Quantitative analysis was conducted using the average assessment results of students in the summative scope of the previous material and after the application of the method in the scope of global warming material.This data is then compared to observe the improvement in learning outcomes.Test results data were analyzed using descriptive statistics, such as mean, standard deviation, and distribution of assessment results to understand the patterns of students' understanding improvement.The

results of this analysis are used to evaluate the effectiveness of the applied teaching methods and to provide recommendations for further implementation in science education.

RESULTS AND DISCUSSION

The application of STEAM-based and Cooperative learning in the Global Warming material resulted in increased student engagement and understanding of the concepts being studied.This is evident from the various stages of activities carried out, starting from the creation of infographics, simple experiments, to evaluations based on Google Forms.

The Process of Creating Infographics

The creation of infographics has become one of the forms of creative assessment in this learning process.Students are given the freedom to use Canva to design their infographics, which include information about the definition of global warming, its causes, impacts, and solutions.Each group discusses to create the best design before selecting one outstanding infographic to be uploaded on the Instagram of the MAN 1 Kota Bekasi Library for voting. Observation results show that creating infographics enhances students' understanding in systematically organizing information (Marcelle et al., 2024), analyzing scientific data (Bai, 2023), and visually communicating their ideas (Hanson, 2022). Some challenges faced by students at this stage include selecting the appropriate content, design skills, and accurate data organization.However, with guidance from teachers and group discussions, students can complete this task with fairly good results.

The Infographic Results Created by Students

The infographics produced show an improvement in students' conceptual understanding. Most of the designs created have attractive visuals, informative content, and a strong connection to the Physics concepts related to global warming. The diversity of the designs created also reflects that the students are capable of developing their own ideas and applying the concepts they have learned in visual form. Examples of infographics created by students are presented in Figures 1 and 2. The infographic selected by the group representative is presented at the following Instagram link: https://www.instagram.com/perpus.mansasi/p/DGj3VIBPQ6t/?hl=en.

Figure 1. Infographic by group 1

Figure 2. Infographic by group 5

Simple Experiment on Greenhouse Effect Modeling

To deepen their understanding of the concept of global warming, students conducted a simple experiment modeling the greenhouse effect.This experiment allows students to compare temperature differences between closed and open environments, simulating how greenhouse gases trap heat in the Earth's atmosphere. The results of the experiment showed that each group obtained varying data depending on the environmental factors at the time the experiment was conducted. Through class discussions, students can analyze their observation results and relate the data obtained to scientific theories. This process helps them understand how the phenomenon of global warming works scientifically and how its effects can be measured directly.

Figure 3. Simple global warming experiment

Assessment through Google Form

To assess students' understanding quantitatively, an assessment was conducted using Google Form.The assessment results show a significant improvement in student understanding, with the average assessment score increasing from 64.03 (Renewable Energy Material) to 85.89 (after the implementation of the STEAM and Cooperative methods on Global Warming material).

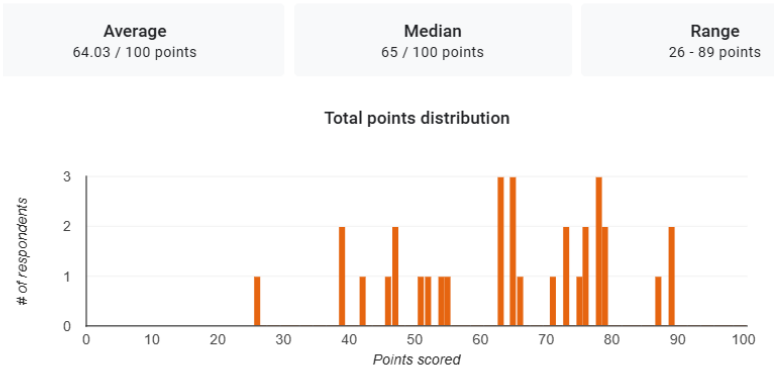

Figure 4. Results of the renewable energy training assessment

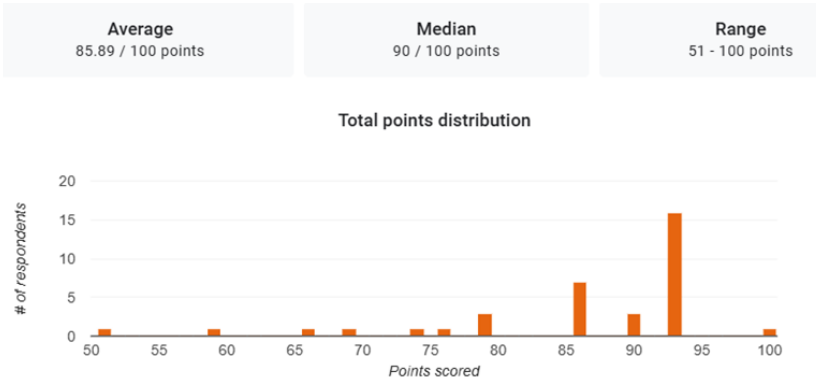

Figure 5. Results of the global warming training assessment

A significant increase in the average assessment results indicates the effectiveness of the learning approach applied in the global warming material.One of the factors contributing to this increase is the contextual approach, where the Global Warming material is more relevant to students' daily lives. Context-based learning helps students connect abstract concepts with real-life experiences, thereby enhancing their conceptual understanding and memory (Baydere, 2021). Additionally, the use of discussion and collaboration methods in the Global Warming chapter provides opportunities for students to build understanding socially, as emphasized in Vygotsky's social constructivism theory (Zummo, 2023).

In terms of data distribution, in the Renewable Energy material, a median of 65 with an assessment range of 26–89 indicates a more dispersed distribution and many students still have difficulty understanding the concept.Meanwhile, in Global Warming, the median increased to 90 with a range of 51–100, indicating that most students were able to achieve high assessment results.This distribution shows that the methods applied in the Global Warming chapter are more effective in uniformly improving students' understanding. These findings are consistent with previous research, which states that learning based on active interaction, including group discussions and the use of visual media, has a significant impact on student learning outcomes (Ng et al., 2020; Xhomara & Dasho, 2023). In addition, the use of more engaging media, such as interactive videos and simple experiments, is also likely to be a factor in improving students' understanding of Global Warming material (Barcena-Vazquez et al., 2023).

The results of this learning not only impact students' understanding of the concept of global warming but also contribute to fostering better environmental awareness.This is in line with the Sustainable Development Goals (SDGs) Goal 4 (Quality Education) and Goal 13 (Climate Action), where innovative educational approaches are expected to enhance scientific understanding and awareness of environmental issues. In addition, the success of this method in enhancing student engagement and learning outcomes also supports the vision of Indonesia Gold 2045, which aims for the development of superior human resources with critical, creative, and technology-based thinking skills.One student shared their opinion about this lesson, *"In my opinion, this chapter is much more interesting compared to the previous one because through hands-on practice, I can understand the concept of global warming better."* In addition, the material is presented in an easy-to-understand manner, so I

feel I enjoy the learning process more. With more and more students understanding the concept of global warming, it is hoped that they can become a generation that is more caring and active in seeking solutions to environmental problems in the future.

CONCLUSION

Based on the results of this best practice, it can be concluded that STEAM-based and Cooperative learning is effective in enhancing students' understanding of the concept of Global Warming.This model encourages students to be more active in the learning process, enhances their critical thinking skills, and develops their creativity through technology-based projects. The success of this method also shows that a more interactive learning approach can contribute to achieving Indonesia's SDGs, especially in improving the quality of education and raising awareness about climate change.Although there are still challenges in its implementation, the results obtained show that this method can be an effective solution in increasing student engagement and learning outcomes.

As a recommendation, further research can be conducted with a broader scope to measure the long-term impact of this method.Additionally, deeper integration of technology, such as the use of digital simulations and augmented reality, could be the next innovation in enhancing the effectiveness of STEAM and Cooperative-based learning.

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