

Implementation of Problem-Based Learning to Enhance Students' Higher Order Thinking Skills and Interest in Global Warming Material

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Article Info	Abstract
Article history: Received: June 1, 2024 Revised: January 2, 2025 Accepted: January 29, 2025 Keywords: HOTS PBL Student interest This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License © 2025 Berkala ilmiah Pendidikan Fisika	This study aims to determine how implementing the problem-based learning (PBL) model has improved students' higher-order thinking skills (HOTS) and their interest in global warming material. This study employed a descriptive method intended to accurately describe a variable, phenomenon, or condition as it exists. A one-group pretest-posttest design was used in this study, with one classroom serving as the sample. The sample for this study was selected from class X-E of SMAN 1 Ngaglik in the 2023/2024 academic year, which consisted of 31 students, using a lottery-based random sampling method. A HOTS test was administered to measure the abilities in analysis, evaluation, and creation defined in Bloom's taxonomy to collect data. Furthermore, participants were required to submit an interest questionnaire. The interest questionnaire used indicators of interest, including 1) student interest, 2) the feeling of pleasure, 3) student involvement, and 4) student attention. Students' HOTS on global warming material showed a significant improvement, with an N-gain score of 0.67 and scores rising from 54.84 to 85, classified as moderate. Students' interest in global warming material increased from a score of 37.76 to 78.71, with an N-gain score of 0.66, also categorized as moderate. The results of the paired sample t-test on HOTS and student interest showed the same result, namely, Sig (2-tailed) value of $0.000 < 0.05$. The paired t-test results and the percentage of normalized gain score, show that the PBL model can be used to significantly enhance students' HOTS and interest in global warming material. The results of this study provide teachers with practical suggestions for establishing innovative, meaningful, and rich learning environments that foster students' intellectual curiosity and improve their HOTS.
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INTRODUCTION

Education is essential in equipping the younger generation to confront future obstacles in the dynamic era of globalization. HOTS are essential abilities, including critical thinking, analysis, creativity, and problem-solving ([Arthur et al., 2023](#); [Brookhart, 2010](#); [Sofyan et al., 2024](#)). HOTS is a 21st-century competency that students must possess and is one of the essential components of innovative learning ([Fitriyati et al., 2024](#); [Rahayu & Alsulami,](#)

2024). HOTS is an important skill to be developed in students because it enables them to think critically, creatively, and innovatively, analyze problems, interpret, evaluate, and solve problems with various solutions ([Arthur, 2023](#); [Atmaja et al., 2024](#); [Istiyono et al., 2019](#); [Misrom et al., 2020](#); [Yusuf et al., 2021](#)). HOTS involves higher-level thinking skills, encompassing analysis, evaluation, and creation according to Bloom's taxonomy ([Eka Putra & Iswantir, 2021](#); [Istiyono et al., 2019](#); [Rahayu & Alsulami, 2024](#); [Septiani & Hidayati, 2022](#); [Shavelson et al., 2018](#); [Sofyan et al., 2024](#);). Teachers must foster students' HOTS in the 21st century by implementing innovative and appropriate teaching strategies or models ([Fitriyati et al., 2024](#); [Yulianti et al., 2020](#); [Yusuf et al., 2021](#)).

The PBL model has been acknowledged as an effective method for developing HOTS. PBL prioritizes students as the primary focus of learning, presenting them with real-life challenges that necessitate collaborative problem-solving and investigation ([Barrows & Tamblyn, 1980](#); [Eka & Iswantir, 2021](#); [Meke et al., 2019](#); [Nurhayati et al., 2021](#)). PBL imparts academic content to students and fosters the development of critical, creative, and analytical thinking skills essential for resolving intricate problems ([Hmelo-Silver, 2004](#); [Meke et al., 2019](#)).

Global Warming is a core physics topic that Class X students must grasp under the Merdeka Curriculum. With learning outcomes, students are expected to be able to observe, question, conduct investigations, and analyze data and information related to global warming in everyday life. This material necessitates that students generate their own knowledge through problem-solving autonomously. Consequently, it is necessary to implement an instructional method that prioritizes students, encourages active participation, and cultivates critical thinking skills.

The learning process at SMA Negeri 1 Ngaglik Yogyakarta is primarily teacher-centered, as evidenced by field studies conducted with class X students. The teacher plays a more active role in the lessons. Traditional, informative teaching methods continue to be employed in the classroom for teaching physics. As a result, students primarily receive knowledge directly from the teacher rather than developing it independently through active learning strategies. As a result, students' HOTS are very low. This is evidenced by the fact that nearly 70% of the students in the class have been unable to meet the criteria for achievement of learning objectives (KKTP) due to a lack of instruction that can enhance their thinking skills.

Teachers have been unable to engage students in the learning process, ensure they experience meaningful and pleasurable learning, and cultivate their interest, happiness, and full attention to the subject matter. Teachers are uncommonly adept at incorporating technology into the classroom. Teachers frequently employ textbooks as educational resources and perceive them as adequate. Meanwhile, in order to satisfy the requirements of the 21st century, teachers must incorporate technology into their teaching practices and implement student-centered learning strategies that foster active engagement, critical thinking, and interest. Consequently, the classroom experience is transformed into engaging, innovative, creative, profound, and enjoyable.

Previous research has demonstrated that PBL is effective in improving HOTS. For instance, [Chamidah and Suhartono \(2022\)](#) discovered that the implementation of PBL and STEM at Hang Tuah 4 Surabaya High School significantly influenced the HOTS abilities of students. This study showed that students who engaged in PBL could analyze and solve complex problems more than students who learned through conventional methods. Compared to students who learn through conventional methods, students who learn through PBL were more adept at communicating, analyzing, and solving problems ([Hasrawati et al., 2020](#); [Hidayat & Taufiqurrahman, 2022](#); [Rahmi et al., 2022](#); [Yanti, 2017](#)).

Students' interest in learning is also an important factor that can be improved through PBL and HOTS. [Dewey \(1913\)](#) stated that interest is a person's involvement, pleasure, and

full engagement in an activity. Consequently, interest is one of the factors that can affect an individual's actions, which can also impact the academic achievement of students ([Azmidar et al., 2017](#); [Putra & Setyaningrum, 2018](#)). Attention to students' learning interests is essential for teachers. Nevertheless, in practice, a significant number of students are still less engaged in the learning process, which is attributed to a lack of student interest ([Firduas & Sulandra, 2021](#)). Therefore, innovative teaching strategies are needed to increase students' interest in learning. In their research, [Firduas & Sulandra \(2021\)](#) and [Maidan et al. \(2020\)](#) identified the following indicators of student interest that should be considered when learning: attention, the feeling of pleasure, involvement, and interest. Meanwhile, [Mujahidawati et al. \(2024\)](#) stated that the indicators of student interest include: students' feelings, interest and attention, and involvement.

A high level of learning interest encourages students to become more actively engaged in the learning process. [Rahmi et al. \(2022\)](#) conducted research that showed the PBL model effectively increased student motivation in chemistry at SMA Negeri 1 Payakumbuh. The research determined that students were more inclined to partake actively in problem-solving activities and group discussions due to the direct involvement that PBL affords them.

Another study by [Eka and Iswantir \(2021\)](#) showed that while implementing HOTS through PBL faced challenges, it still effectively enhanced students' critical thinking abilities. Despite implementation difficulties, PBL successfully developed students' cognitive skills. Furthermore, students who engaged in PBL demonstrated elevated levels of motivation and engagement due to the problem-solving and challenging nature of the learning process.

[Nurhayati et al. \(2021\)](#) conducted research that demonstrated that PBL can enhance students' analytical and creative skills in physics. These results are consistent with previous research that has demonstrated the efficacy of PBL in enhancing students' HOTS in various disciplines. In her research, [Amelia \(2019\)](#) demonstrated that STEM-based Problem-Based Learning can significantly improve students' problem-solving skills in mathematics. This research further supports the conclusion that PBL enhances students' problem-solving abilities and improves critical thinking skills.

A meta-analysis by [Mayasari et al. \(2023\)](#) demonstrated that PBL significantly improves students' conceptual understanding and HOTS. The study examined 20 articles published in Sinta-accredited journals and determined that PBL has been demonstrated to be adaptable in improving a diverse array of student competencies across various educational levels.

Implementing PBL in high schools in Indonesia continues to encounter various obstacles, including inadequate teacher training and limited resources. Nevertheless, research indicates that PBL can be effectively implemented to improve students' enthusiasm for learning and their HOTS with the appropriate support ([Putri & Sari, 2021](#)). PBL cultivates a cooperative and dynamic learning environment that motivates students to engage in the learning process. Consequently, teachers and policymakers must incorporate PBL into the curriculum to prepare students for the challenges of the 21st century ([Widyastuti & Kurniawan, 2019](#)).

Improving students' HOTS requires incorporating contextual dilemmas into the learning process during the implementation of PBL ([Paputungan et al., 2022](#)). Additionally, virtual simulations can be implemented in the learning process to facilitate a more contextual comprehension of the issues at hand ([Liana et al., 2023](#); [Rianti et al., 2024](#)). The absence of contextual problem delivery and virtual simulations in prior research has led to subpar HOTS performance among students, particularly in the categories of evaluation and creation ([Arviani et al., 2023](#); [Prakash & Litoriya, 2022](#); [Royantoro et al., 2018](#); [Wijnen et al., 2022](#); [Yusuf & Widyaningsih, 2018](#)). Therefore, this study will present contextual

problems related to global warming using PhET Colorado-based virtual simulations, videos, and digital learning resources.

This study aims to evaluate the efficacy of PBL in enhancing students' interest in global warming material and their HOTS, as indicated by the aforementioned explanation. This research aims to offer teachers valuable insights for improving student learning and engagement in physics by incorporating technology such as PhET Colorado simulations, videos, and digital learning resources and implementing PBL.

METHODS

A quantitative descriptive research design was employed for this study. According to [Rukajat \(2018\)](#) descriptive research aims to accurately and realistically depict phenomena as they occur in the present. This study employed a pre-experimental one-group pretest-posttest design. The population consisted of all class X in semester 2 of SMAN 1 Ngaglik in the 2023/2024 academic year, with 214 students. A single class was randomly selected through a lottery method as the sample, namely Class X-E, comprising 31 students.

A HOTS test was administered to measure the abilities in analysis, evaluation, and creation defined in Bloom's taxonomy to collect data. Furthermore, participants were required to submit an interest questionnaire. The interest questionnaire employed indicators of interest, including 1) student interest, 2) the feeling of pleasure, 3) student involvement, and 4) student attention.

The normalized gain score (N-gain) was determined by analyzing the HOTS test and interest questionnaire at the commencement and conclusion of the learning process, and a paired sample t-test was conducted thereafter. The procedures of this research are presented in Figure 1.



Figure 1 The procedures of the research

As illustrated in Figure 1, the activities that were undertaken during the preparation stage included the development of a research plan, the identification of the research location and sample, the request for research permission from the School Principal, the development of research instruments, including teaching modules, HOTS tests, and student interest questionnaires, and the validation of the instruments in accordance with the recommendations of experts. Three content experts validated the HOTS test and student interest questionnaires. The HOTS test comprised ten multiple-choice items. Multiple-choice tests can be used to assess HOTS. According to [Haladyna \(2004\)](#), well-designed multiple-choice questions can include complex scenarios that require students to think critically, analyze information, and choose the most appropriate solution, which are essential characteristics of HOTS. [Brookhart's \(2010\)](#) research indicates that multiple-choice tests can effectively measure HOTS when the questions push students beyond simple recall of facts. Furthermore, [Tarrant et al. \(2009\)](#) argue that tests with fewer, but deeply contextual and well-constructed items can still be effective in assessing various skills, including HOTS. All HOTS test items were determined to be valid, and the student interest questionnaire was composed of fifteen items rated on a five-point Likert scale ranging from Strongly Disagree to Strongly Agree.

The sample class was subjected to the PBL model during the implementation phase. This study employed technology-based simulations from PhET Colorado and videos not employed in previous research, including those conducted by [Royantoro et al. \(2018\)](#) and [Arviani et al. \(2023\)](#). Contextual issues that may arise in the student's daily activities are

the subjects of this study. The utilization of contextual issues is consistent with the research conducted by [Paputungan et al. \(2022\)](#), which established that contextual problems can promote the development of HOTS in students. According to [Royantoro et al. \(2018\)](#), students accustomed to solving problems will develop their thinking skills. Additionally, simulations like PhET Colorado have enhanced student engagement, problem-solving skills, and conceptual understanding in physics learning ([Liana et al., 2023](#); [Rianti et al., 2024](#)). Research by [Nafi'ah et al. \(2019\)](#) also emphasizes that contextual materials relevant to students' everyday lives can aid in developing HOTS. Consequently, integrating simulations such as PhET and Problem-Based Learning (PBL) fosters the development of students' HOTS and creates a more interactive learning environment.

This study aims to train students' HOTS, including analyzing, evaluating, and creating, through contextual problems derived from everyday life. Students participate in activities with experimental objectives during the initial session, including the following: 1) analyzing the mechanism of the greenhouse effect, 2) analyzing the greenhouse effect phenomenon based on gas concentrations, 3) analyzing the greenhouse effect phenomenon based on historical data/time, 4) analyzing the greenhouse effect phenomenon based on cloud presence, 5) concluding the main factors contributing to greenhouse gas emissions and, 6) designing effective solutions to mitigate these emissions. In the problem-solving activities, students are provided with factual information about the greenhouse effect, including climate change and the recent temperature increases in Yogyakarta. They analyze the issues causing climate change and rising temperatures using the PhET Colorado virtual simulation and explore solutions to mitigate these challenges. Students employ the PhET Colorado virtual simulation to investigate various relationships during the experimental process, including the correlation between temperature and greenhouse gas concentrations, the relationship between temperature changes over time, and the influence of cloud presence on temperature fluctuations.

In the second session, students engage in activities with experimental objectives as follows: 1) analyzing the causes of global warming related to daily activities, and 2) implementing waste management strategies based on the 4R principles (Reduce, Reuse, Recycle, Replace) to reduce the impact of global warming. In the problem-solving activities, students are presented with a video depicting various daily activities, such as using laptops or smartphones, burning waste and land, planting trees, conserving electricity, excessive use of air conditioning, motor vehicle usage, and forest burning. Additionally, images and videos showing different types of waste commonly found in daily life are provided. Students are responsible for examining the daily activities contributing to global warming and devising solutions to mitigate them. Additionally, they formulate waste management strategies predicated on the 4R principles to mitigate the consequences of global warming.

These two activities are worksheets that are incorporated with the PBL model, PhET Colorado, and video media. It is anticipated that the contextual activities will address shortcomings of previous studies, which demonstrated that the PBL model employed did not have a comprehensive impact on students' HOTS, particularly in the categories of evaluating and creating ([Arviani et al., 2023](#); [Prakash & Litoriya, 2022](#); [Royantoro et al., 2018](#); [Wijnen et al., 2022](#); [Yusuf & Widyaningsih, 2018](#)).

Consequently, the HOTS test and the student interest questionnaire were administered before and after the learning sessions during the data collection phase. Data from the HOTS test and interest questionnaires underwent data analysis. The normalized gain score (N-gain) was computed, followed by a paired sample t-test.

RESULTS AND DISCUSSION

Higher Order Thinking Skills

The overall HOTS of students on global warming can be seen in Figure 2.

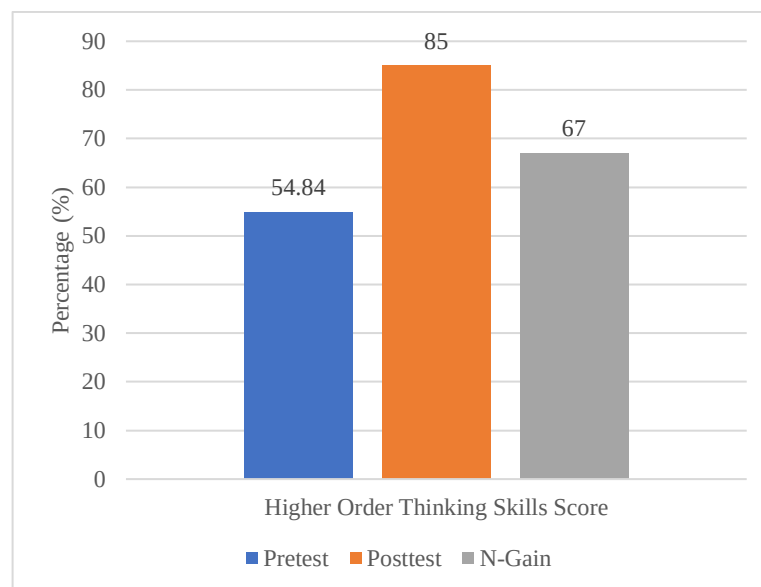


Figure 2 Graph of overall HOTS

Based on Figure 2, students' HOTS increased from a score of 54.84 to 85. This was analyzed using the normalized gain score percentage, 67 (N-gain score 0.67), categorized as moderate. This result was reinforced by the paired sample t-test and obtained a sig value (2-tailed) value of $0.000 < 0.05$, showing a significant improvement in students' HOTS from the pretest to the post-test. The results of the paired sample t-test for HOTS are presented in Table 1.

Table 1 Paired sample t-test results for HOTS

	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pretest – Post-Test	-30.16129	7.35797	1.32153	<.001

The difference between the pretest and post-test scores indicates that PBL effectively enhances students' HOTS when applied to Global Warming material. This enhancement is directly linked to the technology-integrated PBL model, which fosters a student-centered learning environment. By implementing PBL in the learning process, students are encouraged to learn by solving real-world problems that are relevant to their lives. In the context of global warming, students are presented with problems such as "How can we reduce the impact of global warming?" or "What is the best solution to address the impact of global warming? How can we manage waste in the surrounding environment?"

Teachers design learning in accordance with the PBL syntax when implementing PBL. The learning process using PBL on the material of global warming is as follows: 1) in the orientation to the problem stage: the teacher presents a problem that is relevant to students' lives, for example, the impact of global warming on their surroundings, 2) in the organizing students for learning stage: students are divided into small groups to work together in solving problems, 3) in the guiding individual and group inquiry stage: each group formulates questions that need to be answered to solve the problem, determines relevant information sources, and makes an investigation plan, 4) in the conducting inquiry stage: Students seek information from various sources, such as books, scientific articles, the

internet, or interviews with experts, 5) in the developing and presenting results stage: Each group presents the results of their investigation, including the solutions they propose to address the problem of global warming, and 6) in the analyzing and evaluating the problem-solving process stage: the whole class together analyzes and evaluates the various solutions that have been proposed, and draws conclusions.

PBL is a student-centered approach where learners explore a subject by collaborating in groups to solve open-ended problems. These problems serve as the driving force for motivation and learning. According to [Nilson \(2010\)](#), a well-designed PBL project provides students with opportunities to develop various skills, including: 1) teamwork, 2) project management and leadership, 3) oral and written communication, 4) self-awareness and group process evaluation, 5) independent work, 6) critical thinking and analysis, 7) concept explanation, 8) self-directed learning, 9) applying course content to real-world scenarios, 10) research and information literacy, and 11) interdisciplinary problem-solving. Implementing PBL in physics learning, especially on global warming material, can effectively improve students' HOTS. By allowing students to be actively involved in the problem-solving process, PBL can help students develop skills highly needed in the 21st century, such as critical, creative, and collaborative thinking. This is consistent with the Merdeka curriculum's objectives of fostering holistic and contextual learning and developing students' critical thinking abilities. Using video-based learning media with virtual lab-based student worksheets, such as PhET Colorado, can also improve student engagement during the learning process.

HOTS by Ability Aspect

The study examined students' abilities in analyzing, evaluating, and creating, which are core indicators of HOTS. Student's HOTS by ability aspect can be briefly explained in Figure 3.

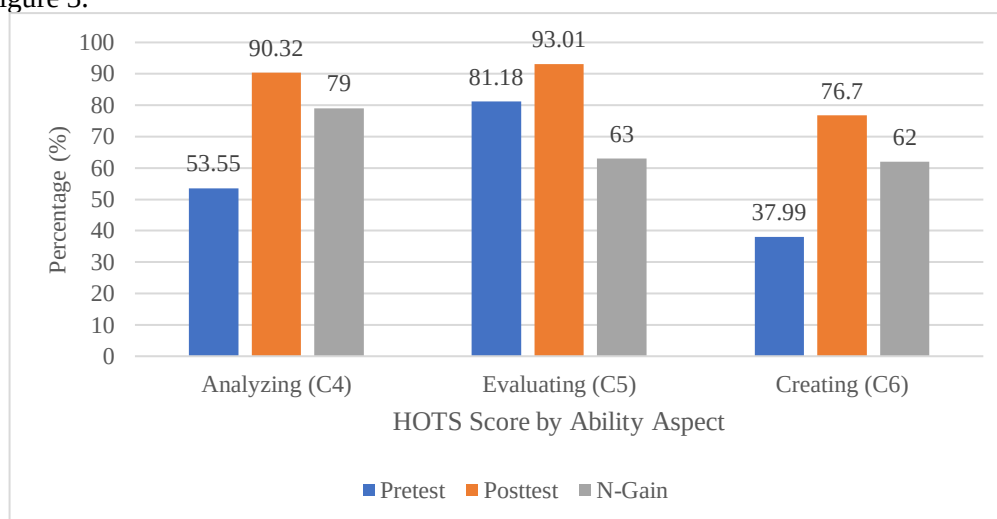


Figure 3 Graph of HOTS per ability aspect

Based on Figure 3, all three aspects of HOTS showed a significant improvement. The analyzing ability increased from a score of 53.55 to 90.32, with a normalized gain score percentage in the high category at 79 (N-gain score 0.79). The evaluating ability improved from 81.18 to 93.01, with a normalized gain score percentage in the moderate category at 63 (N-gain score 0.63). The creating ability rose from a score of 37.99 to 76.7, with a normalized gain score percentage in the moderate category at 62 (N-gain score 0.62).

The analyzing aspect experienced the highest increase, while the creating aspect experienced the lowest increase. This is because the PBL model teaches students to more

thoroughly analyze and evaluate contextual problems that are presented at the beginning of the learning process. Students can autonomously construct their knowledge; however, they have not yet become accustomed to formulating solutions to the problems they are presented with.

Improving students' HOTS in global warming material for each aspect of HOTS has shown that integrating technology with a problem-based learning model can substantially improve students' HOTS. PBL encourages students to make rational decisions, analyze information, evaluate alternative solutions, and think critically. Several HOTS, including analysis, synthesis, and evaluation, are indirectly trained by this process. In the analysis stage, students analyze data, information, and various perspectives related to the issue of global warming. They compare and contrast the various factors that influence this problem. In the synthesis stage, students combine the information they have gathered to form a comprehensive understanding of global warming. They will also develop innovative solutions based on their understanding. In the evaluation stage, students evaluate various possible solutions, weighing the pros and cons of each and choosing the most effective and relevant solution. The problem of global warming is addressed by PBL, which encourages students to think "out of the box" and develop new ideas and innovative solutions. Students are instructed to identify issues, develop hypotheses, gather data, analyze it, and derive conclusions. The PBL model effectively trains students to construct their knowledge in every aspect of HOTS, develop their communication, reasoning, problem-solving, and self-assessment skills, and ensure that they understand the material concepts ([Akmalia et al. 2016](#); [Hidayat & Taufiqurrahman, 2022](#); [Meke et al., 2019](#)).

Student Interest

Students' overall interest in global warming can be seen in Figure 4.

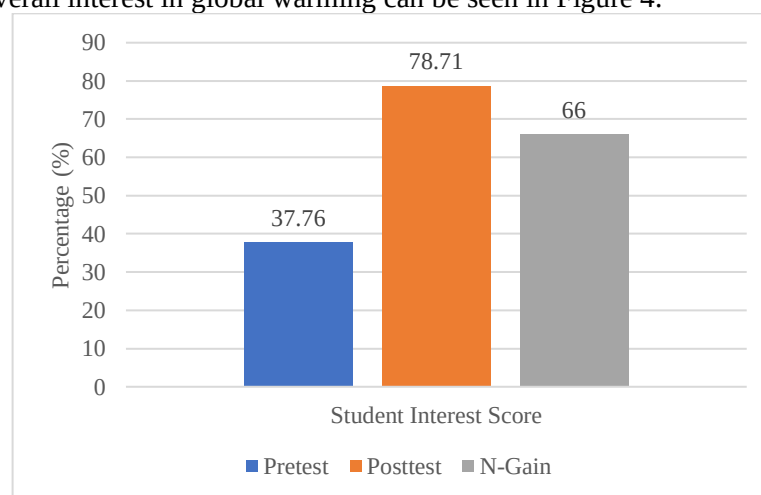


Figure 4 Graph of overall learning interest of students

Based on Figure 4, students' learning interest in global warming material has increased from a pretest score of 37.76 to a post-test score of 78.71. This was analyzed using a normalized gain score of 66 (N-gain score 0.66), falling within the moderate improvement range. These results are reinforced by the paired sample t-test, which obtained a sig value. (2-tailed) of $0.000 < 0.05$, indicating a significant difference between the pretest and post-test scores of students' interest. The results of the paired t-test for interest are presented in Table 2.

Table 2 Paired sample t-test results for student interest

	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pretest – Post-Test	-40.93548	4.67572	.83978	<.001

The difference between the pretest and post-test scores indicates that implementing PBL can enhance students' interest in global warming material. Integrating the PBL model with the PhET Colorado virtual lab technology and using video-based media interests students in following the learning process. In physics learning, technology such as PhET Colorado-based can increase student interest ([Amin & Firdaus, 2023](#); [Fortuna et al., 2024](#)). PhET simulations in problem-based learning will actively engage students, especially during group work sessions, where they are presented with contextual problems and tasked with solving them.

The learning process commences with the teacher introducing a real-world issue associated with global warming, such as the increase in Earth's temperature or the effects of greenhouse gases. Students' investigations and discussions commence with this issue. Subsequently, students collaborate in small groups to comprehend the issue. Through a virtual experiment, they investigate the impact of greenhouse gases on the temperature of the Earth using the PhET Colorado simulation. Students actively engage in simulations, modify variables, and document their findings with interactive worksheets. The teacher is a facilitator, guiding students as they investigate potential solutions.

Students can access digital learning resources, including instructional videos and articles from reputable websites that offer additional information on global warming. Students employ this information to bolster their arguments and enhance their comprehension of the phenomena under discussion.

After collecting data and information, students present their solutions to the global warming problem through digital reports or group presentations. Group discussions enhance students' analytical, creative, and critical reasoning abilities. In addition to acquiring academic concepts, students enhance their communication and collaboration abilities during this process.

This PBL model enables students to engage in the learning process, developing their critical thinking skills and ability to identify practical solutions. The utilization of digital learning materials and technology, such as the PhET Colorado simulation, provides students with a more relevant and meaningful learning experience, thereby fostering their interest in physics

Student Interest by Indicator

Student interest in this study was measured by four indicators: interest, feelings of pleasure, involvement, and attention ([Firduas & Sulandra, 2021](#); [Maidan et al., 2020](#)). Student interest in learning by indicator can be briefly explained in Figure 5.

Based on Figure 5, the four indicators of students' learning interest in global warming material have increased. The student interest indicator has increased with a normalized gain score percentage in the moderate category of 69 (N-gain score 0.69). The feeling of pleasure indicator has increased with a normalized gain score percentage in the moderate category of 75 (N-gain score 0.75). The student involvement indicator has increased with a normalized gain score percentage in the moderate category of 53 (N-gain score 0.53). The student attention indicator has increased with a normalized gain score percentage in the moderate category of 73 (N-gain score 0.73).

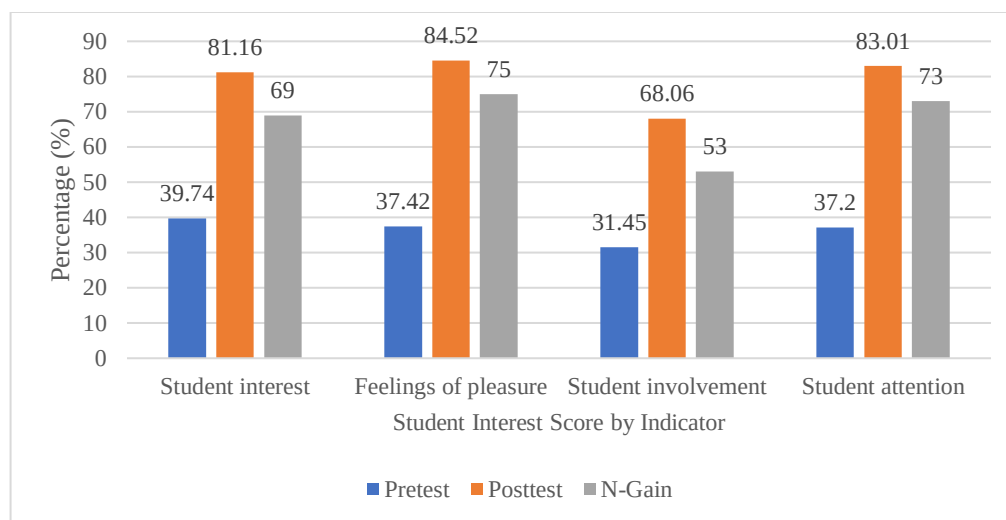


Figure 5 Graph of Students' Interest per Indicator

Based on the N-gain scores for each interest indicator, it is evident that significant increases occurred in the feeling of pleasure and attention indicators, both of which fall into the high category. This indicates that implementing a problem-based learning model integrated with technology can significantly enhance student interest in learning, particularly in these two indicators. Implementing the PBL model allows teachers to facilitate student-centered, innovative, creative, meaningful, and enjoyable learning experiences. Attention to students' interest in learning is crucial because interest influences learning reception ([Simamora & Sianipar, 2022](#)). Students interested in learning are more inclined to engage in learning, diligent, perseverant in understanding, highly concentrated, enthusiastic, and able to set aside other distractions ([Nurhasanah & Sobandi, 2016](#)). This will have a positive impact on improving students' learning achievement ([Azmidar et al., 2017](#)) and students' learning outcomes ([Ernawati et al., 2022](#); [Sagita Devi & Astuti, 2023](#); [Trinova et al., 2022](#)).

CONCLUSION

The data analysis demonstrated a significant overall improvement in students' HOTS when exposed to PBL on global warming, from a pretest score of 54.84 to a post-test score of 85. The percentage of normalized gain score was 67 (N-gain score 0.67), categorized as moderate. The results of the paired sample t-test obtained a sig. (2-tailed) value of $0.000 < 0.05$ reveals a significant improvement in student scores from the pretest to the post-test, suggesting that technology-integrated PBL effectively enhances students' HOTS.

Student interest in global warming increased from a pretest score of 37.76 to a post-test score of 78.71, interpreted using a normalized gain score of 66 (N-gain score 0.66), which falls into the moderate category. The results of the paired sample t-test obtained a sig. (2-tailed) value of $0.000 < 0.05$ indicates a significant improvement in student scores between the pretest and post-test, suggesting that technology-integrated PBL can effectively enhance student interest.

The results of this study provide teachers with practical suggestions for establishing innovative, meaningful, and rich learning environments that foster students' intellectual curiosity and improve their HOTS.

CONFLICTS OF INTEREST

The authors affirm that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

AK (conceptualization, methodology, formal analysis, writing – the original manuscript, visualization), YW (review), UP (resources, investigation, project administration), SDN (writing – review and editing, project administration), and VDP (writing – review and editing, project administration) collectively contributed to the initial preparation of the manuscript.

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