Leveraging E-Games in PBL+Six-Think-Hat Framework to Boost Physics Comprehension Among Students

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Abstract
This study aims to enhance students' learning outcomes in the subject matter of the nature of science and scientific methods through the implementation of a Problem-Based Learning (PBL) model combined with the Six-Think-Hat strategy, supported by e-games. The research adopts a quasi-experimental design with random sampling techniques. The research sample consists of 7th-grade students from class 7G at UPT SMP Negeri 1 Gresik for the academic year 2024-2025. Data collection was conducted using tests and analyzed through paired sample t-tests and n-gain statistics. The results of data analysis indicate a significant difference in students' learning outcomes before and after the implementation of the Problem-Based Learning (PBL) model combined with the Six-Think-Hat strategy supported by e-games in physics education. This study demonstrates high originality by combining the Problem Based Learning (PBL) model with the Six-Think-Hat strategy and e-games, a rare approach in physics education for middle school students. This approach generates significant new knowledge on how to enhance students' learning outcomes in understanding basic science concepts and scientific methods.

Keywords: Problem-Based Learning (PBL), Six-Think-Hat Strategy, E-games in Education, Science Education, Student Learning Outcomes

1. Introduction

The advancement of digital technology has brought significant changes to various aspects of life, including the field of education. This technology offers numerous opportunities to create more interactive and engaging learning environments (Pinto & Leite, 2020). One innovation that is becoming increasingly popular in the world of education is the use of e-games as learning aids (Hussein et al., 2019). E-games enable students to learn through simulation and interaction, which can ultimately increase students' interest and motivation in the learning process (Rodkroh et al., 2013). Although e-games have great potential, their effectiveness in improving students' understanding of complex subjects, such as physics, still requires further research (Drigas & Kontopoulou, 2016).

Physics is often considered one of the most difficult subjects by students. This difficulty arises because physics involves many abstract concepts and the application of complex mathematics (Sulisworo et al., 2017; Widya et al., 2019). Students often struggle to understand these concepts, leading to low interest and poor academic performance (Gok, 2011). Additionally, traditional teaching methods, which typically focus on lectures and problem-solving exercises, are often insufficient to help students deeply comprehend physics concepts (Bachtiar et al., 2021).

Traditional teaching, though still dominant in many schools, tends to focus on the delivery of material by the teacher and lacks engagement of students in critical and analytical thinking processes (Santoso & Lestari, 2019). Students are more often passive recipients of information rather than active participants in learning. This is one factor contributing to students' low understanding of abstract physics concepts (Husnawati & Rakhmawati, 2024). Therefore, a more interactive and collaborative learning approach is needed to enhance students' comprehension.

One approach proven effective in addressing this issue is Problem-Based Learning (PBL). In PBL, students are placed as problem solvers, where they are given real-world situations or relevant problems to solve (Phungsuk et al., 2017). This process not only involves critical thinking skills but also encourages students to collaborate in finding solutions (Rahmatullah et al., 2022). In the context of physics learning, PBL can help students apply abstract concepts to real-world situations, making it easier for them to understand the material (Argaw et al., 2017).

To enrich the learning experience through PBL, the Six-Think-Hat strategy, developed by Edward de Bono, can be applied. This strategy encourages students to think from various perspectives by using six "thinking hats," each representing a specific way of thinking (Sarı et al., 2017). In physics learning, this strategy can help students analyze problems from different perspectives and generate more creative solutions (Darmaji et al., 2019). Thus, Six-Think-Hat can effectively complement PBL in helping students develop a more comprehensive understanding.

In addition to PBL and Six-Think-Hat, the use of e-games also offers great potential for improving students' learning outcomes. E-games allow students to learn through more engaging visualization and interaction compared to traditional methods (Ratheeswari, 2023). In the context of physics learning, e-games can be used to simulate abstract concepts, enabling students to visualize phenomena that are difficult to comprehend theoretically (Cheung & Ng, 2021). With the integration of e-games, students are not only more motivated but also find it easier to grasp the material being taught.

The combination of PBL, Six-Think-Hat, and e-games offers an innovative and comprehensive learning approach. PBL provides relevant and challenging problem contexts (Cos, 2019; Kassymova et al., 2020). Six-Think-Hat encourages students to think creatively from different perspectives, while e-games offer visual simulations that support students' understanding (Aithal et al., 2016). By combining these three methods, it is expected that students will not only become more interested in physics but also be able to understand and apply it in real-world situations (Sari et al., 2020; Sharma et al., 2019).

Although e-games have been extensively researched in the context of education, few studies have combined their use with PBL and Six-Think-Hat in physics learning. Most research on e-games tends to focus on their impact on students' motivation but pays less attention to their effect on deeper scientific concept comprehension. This opens up opportunities for further research to explore the potential combination of these methods in improving student learning outcomes.

This study aims to measure the effectiveness of combining Problem-Based Learning (PBL), Six-Think-Hat, and e-games in enhancing students' understanding of physics concepts, particularly in the subject matter of the nature of science and scientific methods. This research also aims to evaluate the extent of the difference in student learning outcomes before and after the implementation of this method. Thus, this study focuses not only on increasing learning motivation but also on deep conceptual understanding.

The current gap in the literature shows that few studies have explored the integration of PBL, Six-Think-Hat, and e-games in physics learning. Most studies focus on only one of these methods or their application in other contexts. Therefore, this research offers a new contribution by uniting these three approaches in the context of physics education. It is hoped that this will enrich the literature on innovative and interactive teaching methods.

The novelty of this research lies in the use of a combination of PBL, Six-Think-Hat, and e-games in physics learning. This combination has rarely been applied in previous studies, especially in the context of physics education. This research also offers a new perspective on how digital technology, such as e-games, can be integrated with teaching strategies that promote critical and creative thinking.

This study is expected to have a positive impact on the development of more effective and interactive teaching methods, especially in the field of physics. The results of this study are hoped to benefit not only students and teachers but also curriculum developers and educational policymakers. By adopting this approach, it is expected that students will find learning physics more enjoyable and better understand the material.

2. Research Method

This study employs a quasi-experimental method with a pretest-posttest design involving a control group and an experimental group. The study aims to examine the effectiveness of the combination of the Problem-Based Learning (PBL) model, the Six-Think-Hat strategy, and the support of e-games in improving students' physics learning outcomes. The research was conducted in a junior high school in Indonesia, focusing on the subject matter of the nature of science and scientific methods. The quasi-experimental design was chosen because it allows researchers to implement learning interventions and measure their impact by comparing the pretest and posttest results between the two groups.

The population of this study includes all 7th-grade students at the school, while the sample was selected using a random sampling technique to ensure randomness in participant selection. The sample consisted of two classes: one class acted as the experimental group that received instruction using a combination of PBL, Six-Think-Hat, and e-games, while the other class acted as the control group that received instruction using conventional methods. The total number of students involved in this study was 64, with each class consisting of 32 students.

Data collection was carried out using a test instrument consisting of questions related to the understanding of physics concepts, administered during both the pretest and posttest. The data obtained were analyzed using descriptive statistical techniques to describe the distribution of learning outcomes, and a t-test was conducted to test the hypothesis of differences in learning outcomes between the control and experimental groups. Additionally, n-gain analysis was used to measure the improvement in students' understanding before and after the learning intervention.

3. Results and Discussions

At the beginning of the study, a pre-test was conducted to measure students' initial understanding of physics concepts, particularly in the subject matter of the nature of science and scientific methods. This pre-test was administered to two groups: the experimental group, which would receive instruction using a combination of PBL, Six-Think-Hat, and e-games, and the control group, which would use conventional teaching methods. The pre-test results indicated no significant differences between the two groups, meaning that the initial conditions of both groups were relatively the same in terms of their understanding of physics concepts.

After the learning intervention was completed, both groups were given a post-test to measure the improvement in their understanding of physics concepts. The post-test results showed an increase in scores in both groups; however, the increase observed in the experimental group was much more significant than in the control group. The average post-test score in the experimental group was higher compared to the control group, indicating that the combination of PBL, Six-Think-Hat, and e-games had a greater positive impact on students' understanding.

Figure 1. Students Playing an E-game

In the experimental group, there was a significant difference between the pre-test and post-test scores. The average pre-test score of the students in this group was categorized as low, indicating that their initial understanding of physics was still minimal. However, after receiving instruction using PBL, Six-Think-Hat, and e-games, there was a significant increase in the post-test results, demonstrating that students were able to better understand the material following the application of this innovative teaching method.

The control group, which used conventional teaching methods, also showed improvement in the post-test results, but the increase was not as substantial as that in the experimental group. The average pre-test score of the control group was not much different from that of the experimental group, but the post-test score increase in this group was lower. This indicates that conventional methods can still improve students' understanding, though not as effectively as more interactive learning methods like PBL and e-games.

To test the significance of the difference between the pre-test and post-test scores in the experimental group, a paired sample t-test was conducted. The statistical test results indicated a significant difference between the two scores (p-value < 0.05), meaning that the learning intervention using PBL, Six-Think-Hat, and e-games successfully improved students' learning outcomes significantly. This difference shows that problem-based learning and the use of interactive technology can have a large positive impact on students' understanding.

Table 1. Data Analysis Results

Group	Pre-test Mean	Post-test Mean	N-Gain Mean	P-Value (Post-test)
Control	48.11853104	63.7883753	0.280724804	2.07E-05
Experiment	50.12884772	74.79748373	0.468076396	2.07E-05

In the control group, a paired sample t-test was also conducted to examine the difference between the pre-test and post-test scores. The results showed a significant improvement, though the level of significance was lower than that of the experimental group. The improvement in learning outcomes in the control group reaffirms that conventional teaching methods can still enhance learning, although not as much as the more innovative methods applied to the experimental group.

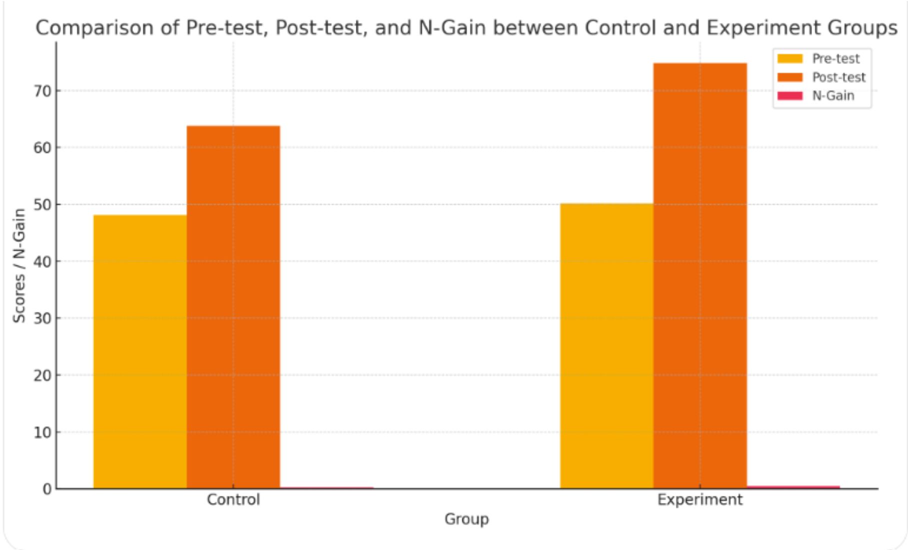

Figure 2. Difference Between Pre-Test and Post-Test Scores

To measure the effectiveness of the improvement in students' learning outcomes, an n-gain analysis was performed. The analysis results showed that the experimental group experienced a significant improvement, with an n-gain value categorized as high. This improvement indicates that the combination of PBL, Six-Think-Hat, and e-games was successful in significantly increasing students' understanding of physics concepts. The n-gain values in the experimental group showed that most students experienced a significant increase in understanding after the learning intervention.

In the control group, an n-gain analysis was also conducted to assess the effectiveness of the learning improvement. The results showed that the n-gain value in the control group was categorized as moderate. This means that although there was an improvement in understanding in the control group, it was not as rapid or substantial as that observed in the experimental group. This indicates that conventional teaching can still enhance students' understanding, but it is less effective compared to more interactive and problem-based methods.

The results of this study indicate a significant improvement in students' learning outcomes after implementing the combination of the Problem-Based Learning (PBL) model, the Six-Think-Hat strategy, and e-games support. This is consistent with the study's initial hypothesis, where the combination of these methods was expected to help students better understand abstract and difficult physics concepts. This approach allows students to actively engage in the learning process, think critically, and explore various perspectives in problem-solving.

The use of the PBL model provides students with the opportunity to face real-world problems relevant to everyday life (Sari et al., 2020). In the context of physics learning, these problems are related to natural phenomena that require an understanding of basic physics concepts. By addressing real-world issues, students are encouraged to think critically and analytically in finding solutions (Sastaviana et al., 2022). The results of this study indicate that students learning with the PBL model show better understanding compared to those using conventional methods.

Figure 3. Learning Activities Using the Six-Think-Hat

The Six-Think-Hat strategy also plays an important role in supporting problem-based learning. This strategy enables students to think from various perspectives using different "thinking hats" (Theron et al., 2024). The results show that students applying Six-Think-Hat were more creative in solving problems and produced more varied solutions. This is important in physics learning, where problem-solving often requires flexible and creative approaches (Aithal & Suresh Kumar, 2017; Susanto et al., 2019).

The support of e-games in learning has proven to increase students' motivation (Freitas, 2018). E-games allow students to learn in a more enjoyable and interactive way (Wiggins, 2016). In this study, e-games were used to simulate physics phenomena, helping students visualize abstract concepts. The findings show that students who learned with the help of e-games were more motivated to actively engage in the learning process, positively impacting their learning outcomes.

In addition to increasing motivation, the use of e-games also contributed to improving students' understanding of physics concepts (Campos et al., 2020). The interactive simulations provided by e-games allowed students to grasp physics phenomena that are difficult to explain through text or static images (Ullah et al., 2022). In this study, students who learned with the assistance of e-games were able to better understand concepts such as force, energy, and the laws of physics. These findings are consistent with previous research, which has shown that e-games can enhance students' understanding in abstract subjects.

Statistical tests show a significant difference in learning outcomes between the experimental and control groups. Students who learned with the combination of PBL, Six-Think-Hat, and e-games showed higher improvement in learning outcomes compared to students using conventional teaching methods. These results suggest that innovative approaches combining problem-based learning, creative thinking strategies, and digital technology can improve the effectiveness of physics education in schools.

The n-gain analysis used in this study shows that the improvement in students' understanding in the experimental group was categorized as high. This indicates that the intervention applied successfully enhanced students' understanding significantly compared to traditional teaching methods. With this improvement, it can be concluded that the combination of PBL, Six-Think-Hat, and e-games is effective in helping students master physics content, particularly in the nature of science and scientific methods.

The findings of this study are highly relevant to the learning objectives, which aim to improve students' understanding of basic physics concepts and scientific methods. The combination of PBL, Six-Think-Hat, and e-games not only significantly increased learning outcomes but also helped students comprehend complex concepts in a more engaging and interactive manner (Argaw et al., 2017; Sharma et al., 2019). The learning objectives were achieved with a significant improvement in students' learning outcomes, especially in the experimental group.

One important element of the PBL model is student collaboration in problem-solving. Collaborative learning has proven to be effective in improving students' learning outcomes. In this study, students working in groups to solve problems showed better understanding compared to students learning individually. This collaboration encouraged students to share ideas, support each other, and seek solutions together, ultimately enhancing their understanding of physics concepts.

The results of this study have important implications for the development of physics education curricula in schools. The innovative approach combining PBL, Six-Think-Hat, and e-games can be an effective alternative to overcoming the challenges of physics learning, which is often considered difficult by students (Baran et al., 2018). The use of this method in the curriculum can help significantly improve students' learning outcomes and motivate them to become more interested in the subject of physics. Additionally, the integration of digital technology in learning can provide a learning experience that is more relevant to modern advancements.

4. Conclusions

Based on the results of the study, it can be concluded that the use of a combination of Problem-Based Learning (PBL), the Six-Think-Hat strategy, and e-games significantly improves students' learning outcomes in physics, particularly in the concepts of the nature of science and scientific methods. The greater improvement in the experimental group compared to the control group indicates that interactive learning approaches involving problem-solving and digital technology are more effective in helping students understand abstract concepts. Statistical analysis, both through paired sample t-tests and n-gain, showed significant differences between pre-test and post-test results, with higher improvement in the group using this innovative method.

The findings suggest that the integration of problem-based learning strategies, creative thinking through the Six-Think-Hat method, and the use of e-games as interactive tools can be an effective solution for enhancing students' understanding of complex concepts. This method not only improves learning outcomes but also motivates students to actively engage in the learning process. Therefore, this approach has the potential to be more widely applied in physics education and other subjects that require deep conceptual understanding.

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