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The Influence of Physics Teachers' Learning Methods on Learning Outcomes in Students

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ABSTRACT
This study aims to analyze the differences in physics learning outcomes between students who are taught with game-based learning, experimental, and cooperative learning methods. The research method used a pseudo-experimental design with three treatment groups. Participants consisted of 33 students in class X who were given 3 learning method treatments: game-based learning, experimentation, and cooperative learning. Data was collected through learning outcome tests and interviews with teachers and students. Statistical analysis using one-way ANOVA showed a very significant difference between the three methods (F=53.03; p=3.06E-16). The highest average learning outcomes were achieved by the game-based learning group (81.82), followed by experimentation (87.58), and cooperative learning (93.3). The results of the interviews revealed that the experimental method was preferred by students because it was interactive and contextual. This study concludes that the selection of innovative learning methods in accordance with the characteristics of the material can significantly improve students' physics learning outcomes.

INTRODUCTION

Physics is a science that studies natural situations related to matter and energy and the interaction between the two [1]. Physics is one of the subjects that is known to be abstract and challenging for most students, so it often causes low learning outcomes and learning motivation. Various factors also affect the success of learning physics, including learning methods, availability of laboratory facilities, and students' learning interests. The development of technology and the rise of digital entertainment can reduce students' interest in learning, so an innovative, interesting, and able learning strategy is needed to increase student involvement in the learning process [1].

Learning methods have an important role in helping students understand physics concepts effectively. The right method makes it easier for students to learn the material, so that the better the method or stages used by the teacher, the higher the success of students in achieving learning goals [2]. In the context of physics learning, active methods such as demonstrations, experiments, and practicums have long been recognized as effective for improving concept understanding, critical thinking skills, and science process skills.

The demonstration method, for example, has been shown to facilitate the understanding of concepts through direct observation. The application of demonstrations to elasticity materials resulted in a significant improvement in students' skills [3]. Interactive demonstrations also make the concepts of temperature and heat easier to understand [4]. The integration of demonstrations into the Problem Based Learning (PBL) model on Newton's Law topics has been shown to significantly improve students' problem-solving abilities [5]. The findings confirm that the demonstration not only clarifies abstract concepts, but also encourages students to actively investigate and discuss.

In addition to demonstrations, practicum-based and experiment-based learning has also been proven to improve understanding of concepts and learning outcomes. Practicum allows students to gain concrete experience, which is the core of experiential learning [6]. The experimental method is carried out through scientific steps starting from observation to drawing conclusions, so as to be able to improve the skills of the scientific process [7]. Various studies support the effectiveness of the practicum method: practicum on optical materials significantly improves conceptual understanding [8]; there is a large difference in learning outcomes between the practicum class and the discussion class [9]; science learning outcomes increased from 57.00 to 90.00 after practicum [10]; and the measurement practicum has an effectiveness of up to 96% [11].

However, the low activity of physics practicum in schools is still an obstacle. The lack of laboratory activities causes weak student competence in solving authentic physics problems [12]. The skill of using measuring instruments only contributes 14.7% to the understanding of the concept of quantities and units, so the learning of measuring instruments must be integrated with the reinforcement of concepts [13]. Efforts to improve conceptual understanding can also be strengthened through interactive multimedia based on guided inquiry [14] and structured measurement tool training in the laboratory [15].

On the other hand, learning innovations in the form of game-based learning are increasingly being applied to increase student motivation and involvement. Game-based learning utilizes elements of challenge, competition, and reward, so that it is able to create a fun and contextual learning experience. This method has been shown to be effective in increasing students' interest and learning outcomes in physics [16]. This approach is also relevant to overcome the low interest in learning due to the technological distractions mentioned earlier [1].

Group work-based learning such as cooperative learning also plays an important role in improving concept mastery. An active and student-centered learning model can improve critical thinking skills and understanding of physics concepts [17]. In cooperative learning, interaction between students encourages the process of elaborating knowledge, discussion, and helping each other understand challenging concepts.

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Although these studies have shown the effectiveness of demonstrations, experiments, practicums, and game-based learning, most studies were conducted separately and only compared one or two methods at a time. Previous research has tended to focus on the effectiveness of practicums or experiments in improving concept understanding [6], [7], while research on game-based learning has more highlighted increased student learning motivation [16]. However, research that simultaneously compares the three methods in the context of physics learning is still very limited, so the relative effectiveness of each method cannot be seen comprehensively. In addition, most previous studies only relied on quantitative data in the form of test results without integrating qualitative data such as teacher and student perceptions, even though the integration of both types of data can increase the validity of findings and provide a more holistic picture of the learning process [14].

Based on the research gap, the novelty of this research lies in conducting a direct comparison of three learning methods namely cooperative learning, experimentation, and game based learning within the same measurement design, combining quantitative analysis (ANOVA) with qualitative data obtained from teacher and student interviews, and providing the latest empirical evidence on the effectiveness of various physics learning methods in the context of secondary schools in Indonesia. Thus, this study not only fills the gap in the literature that has not yet compared the three methods simultaneously, but also makes a methodological contribution through the integration of quantitative and qualitative approaches. This study aims to analyze the differences in physics learning outcomes between the three learning methods, so that it can be the basis for choosing the most appropriate learning strategy to improve students' physics learning outcomes.

METHOD

This study uses a comparative quantitative design that aims to compare the effectiveness of three physics learning methods, namely cooperative learning, experimentation, and game-based learning. Comparative quantitative research is a type of research that aims to compare two or more groups or conditions to find out the similarities and differences in certain variables systematically [20]. The comparative design was chosen because it allowed researchers to assess differences in learning outcomes from different treatments in the same group [1], [2].

The entire learning process is applied to the same class, and the three methods are given in stages according to the order of learning carried out by PLP students. This design is in line with the principle of repeated measurement in educational research [3]. The research design applied in this study is summarized in Table 1.

Table 1. Research Design

Phase	Activities	Output
1	Physics teacher interview	Planning information & learning conditions
2	Interview of 3 students	Perception and learning experience
3	Collection of learning outcomes from PLP students	Data on learning outcomes on three methods

Phase	Activities	Output
4	Classification of data by method	3 groups dataset (Cooperative, Experimental, Game-Based Learning)
5	One-Way ANOVA analysis using Excel	Output ANOVA (F, F-kritik, p-value)
6	Conclusion drawing	Interpretation of the significance of the difference in methods

Data acquisition is carried out through two main techniques, namely interviews and value documentation. Interviews are used to obtain the learning context and perceptions of students, as suggested in educational studies to reinforce internal validity [2], [4].

The data on learning outcomes were analyzed using One-Way ANOVA because this method is suitable for testing the average difference of more than two treatment groups [1], [3]. The analysis is carried out using Microsoft Excel, so that the statistical calculation process can be replicated and easily accessible.

RESULTS AND DISCUSSIONS

1. Learning Outcome Data

This study involved 33 students in class X who received three learning method treatments: cooperative learning, experimentation, and game-based learning. The value of learning outcomes was analyzed using descriptive statistics to obtain an overview of student performance in each method. A summary of descriptive statistics is presented in Table 2.

Table 2. Student Learning Outcome Data

Learning Model	Average	Std. Deviation	Minimum Score	Maximum Value	N
Cooperative Learning	3.48	3.48	3.48	3.48	3.48
Eksperimen	87.88	87.88	87.88	87.88	87.88
Game-Based Learning	81.67	81.67	81.67	81.67	81.67

The data in Table 2 shows that the cooperative learning method produced the highest average score (93.48), followed by experimentation (87.88) and game-based learning (81.67). This indicates that cooperative learning provides more consistent and stable results, as seen from the low standard deviation (3.85). In addition to the descriptive statistics, the distribution of student scores based on value ranges, frequencies, and percentages is presented in Table 3.

Table 3. Distribution of Student Score Frequency

Value Range	Frequency	Percentage
75–79	11 students	33.3%
80-89	12 students	36.4%
90-100	10 students	30.3%
Total	33 students	100%

2. ANOVA One-Way Test Results

In many educational studies in Indonesia, One-Way ANOVA is used to test whether there is a significant difference in average learning outcomes or scores between three or more groups [19]. The one-way ANOVA test is used to find out if there is a significant difference between the three learning methods. The results of the calculation are shown in Table 4.

Table 4. ANOVA One-Way Test Results

Source of Variation	SS	df	MS	F	p-value	F crit
Between Groups	2187.879	2	1093.939	53.03137	3.06E-16	3.091191
Within Groups	1980.303	96	20.62816			
Total	4168.182	98				

The value of the F calculation (53.03) is much greater than the F of the table (3.09). The p-value = 3.06×10^{-16}, much smaller than 0.05. This means that there are very significant differences between the three learning methods.

The results of ANOVA show that the three learning methods have different influences on students' physics learning outcomes. Cooperative learning produces the highest mean score (Mean = 93.33). This result can be explained by findings in the literature indicating that the cooperative learning model encourages students to engage in discussion, re-explain concepts, and help one another, thereby strengthening their understanding of physics concepts [17]. These findings are consistent with previous studies showing that cooperative learning models, particularly the STAD type, significantly improve physics learning outcomes through interaction among group members and the process of concept elaboration [21]. Other research has also shown that cooperative learning enhances concept retention and problem-solving abilities through collaborative activities and individual accountability [25], [26]. In addition, the cooperative model is considered effective because it provides opportunities for peer instruction, a process that has been shown to improve conceptual understanding in science subjects [27]. Teacher interviews further indicate that discussion is one of the most effective methods, as it encourages students to actively respond to and elaborate on the learning material.

The experimental method occupies a moderate position with a mean score of 87.58. Interview results show that students particularly favor practical activities because they help them understand abstract concepts through direct experience. One student stated, "The most helpful is the practical method, because there are actions and direct examples." The literature also supports that practicum-based learning improves science process skills and conceptual understanding [7], [8], [10]. Other studies confirm that experimental activities significantly enhance science process skills and physics learning outcomes, as students are directly involved in experiments that facilitate observation, analysis, and the drawing of scientific conclusions [22].

Game-based learning produces the lowest mean score (Mean = 81.82). Although previous studies indicate that games can increase learning motivation [16], the implementation of game-based learning in this study was conducted by PLP students, which may have resulted in variations in teaching skills and depth of material that affected learning effectiveness. This finding is consistent with a meta-analysis concluding that while game-based learning is effective in increasing students' interest and motivation in physics, improvements in learning outcomes are highly dependent on the quality of game design and its integration with core learning concepts [23]. Furthermore, teacher interviews revealed that students rarely engage in independent learning at home, which may cause the game approach to direct students' attention more toward the game mechanics than toward deeper conceptual understanding.

The results of ANOVA, which show significant differences between these methods, are also in line with the findings of previous research that the use of digital media such as serious games and active learning can produce significant variations in learning outcomes compared to traditional methods [24]. The results of this study are generally in line with the findings of interviews conducted with teachers and students. The physics teacher explained that the lecture, discussion, and demonstration method so far is considered the most effective because it can make students actively involved and easier to understand concepts. These findings are consistent with quantitative results showing that cooperative learning, which relies on group discussion and interaction, produces the highest scores among the three methods. In addition, teachers also emphasized that the success of learning is greatly influenced by students' learning readiness and initial knowledge before entering the classroom. However, based on student interviews, it is known that most of them rarely do independent learning at home, including not reading the material before learning begins. This condition also explains why methods that require independent involvement and freer exploration, such as game-based learning, actually produce the lowest scores.

Meanwhile, student interviews show that they prefer practical or experimental methods, as hands-on activities and real experiments are considered to help understand abstract concepts. They stated that the practice provides concrete examples and steps that can be observed directly, so that the material feels easier to understand. This student's statement is in line with the quantitative results, where the experimental method provides a fairly high average score although not as high as cooperative learning. This shows that practice is indeed effective in improving understanding of concepts, but its effectiveness can be influenced by time, complexity of procedures, and student readiness.

Overall, teacher and student interviews support the ANOVA results which show significant differences between methods. Methods that require active collaboration such as cooperative learning produce the best performance, practice-based methods provide strong understanding, while game-based learning requires a more structured implementation to be effective in improving learning outcomes.

3. Implications of the Findings

The findings of this study indicate that cooperative learning proved to be the most effective approach in the context of the observed class and can therefore be considered a primary instructional strategy for certain physics topics. The collaborative nature of this method encourages active student participation, peer interaction, and deeper conceptual understanding through discussion and shared problem solving. As a result, cooperative learning is particularly suitable for topics that require conceptual clarification and student engagement, and it may serve as a core approach in classroom instruction to improve overall learning outcomes.

Experimental methods also remain highly effective, especially for learning materials that are concrete and require direct visualization through hands-on activities. Practical experiments help students connect abstract concepts with real phenomena, thereby strengthening conceptual understanding and science process skills. Meanwhile, game-based learning requires more careful instructional design to ensure its effectiveness. Although this approach can enhance motivation and engagement, teachers need to ensure

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that game elements are well integrated with learning objectives so that students remain focused on core physics concepts rather than on gameplay alone. Proper guidance and alignment between game mechanics and instructional content are therefore essential for maximizing the educational value of game-based learning.

CONCLUSION AND SUGGESTION

The results of this study show that the expectation in the Introduction section that there is a difference in effectiveness between cooperative learning, experimentation, and game-based learning has been achieved, evidenced by the significant results of ANOVA and supporting the initial hypothesis. These findings also open up opportunities for further development, such as optimizing the design of each method, applying variations of learning models, or further research by adding other variables such as motivation and student involvement to obtain a more comprehensive picture of the effectiveness of physics learning methods.

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