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The Effect of Discovery Learning Model on Students' Learning Outcomes in Newton's Laws

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Abstract

Physics learning at the senior high school level often encounters problems related to low student motivation and weak conceptual understanding, especially in abstract topics such as Newton's Laws. Teacher-centered instructional practices tend to limit students' active involvement, resulting in unsatisfactory learning outcomes. Therefore, the application of student-centered learning models is required to improve students' engagement and conceptual mastery. This study aimed to examine the effect of the Discovery Learning model on students' learning outcomes in Newton's Laws. The research employed a quantitative experimental approach using a One Group Pretest–Posttest Design involving one experimental class and two replication classes at SMA Negeri 1 Kabila during the 2024/2025 academic year. A total of 75 eleventh-grade students participated in the study. Students' learning outcomes were measured using an essay test assessing cognitive levels of understanding (C2), application (C3), analysis (C4), and evaluation (C5). Data analysis included descriptive statistics, the Liliefors normality test, a one-tailed t-test, and N-Gain analysis. The results showed a significant improvement in students' learning outcomes after the implementation of the Discovery Learning model. The mean posttest scores in all classes exceeded the Minimum Mastery Criterion of 75, with N-Gain values ranging from 0.72 to 0.78, which fall into the high category. The t-test results indicated that the calculated t-values were greater than the critical values, confirming a significant effect of the Discovery Learning model. These findings indicate that Discovery Learning is effective in enhancing students' conceptual understanding and learning outcomes in physics. The study implies that Discovery Learning can be adopted as an effective instructional approach to promote active learning and improve the quality of physics education at the senior high school level.

Keywords: Discovery learning; Learning outcomes; Newton's laws; Physics education; Senior high school

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INTRODUCTION

Education serves as a fundamental gateway to a better quality of life, requiring individuals to strive for achievements ranging from simple to complex levels. It plays a crucial role in enabling individuals to achieve their life goals, as aspirations and expectations are difficult to realize without adequate education. Law Number 20 of 2003 concerning the National Education System of Indonesia emphasizes that education is a deliberate and systematic effort to create learning environments and learning processes that allow students to actively develop their potential. This includes spiritual strength, self-control, personality, intelligence, noble character, and skills necessary for personal development and for contributing to society, the nation, and the state (Ujud et al., 2023).

Physics is a branch of natural science that systematically studies the order of nature through observation, measurement, and analysis of phenomena using mathematical approaches. Physics learning does not merely emphasize memorization of formulas but focuses on conceptual understanding, application of principles, and the development of scientific attitudes that are critical, logical, and objective. However, in practice, many students perceive physics as a difficult and challenging subject, which often results in low learning motivation and suboptimal learning outcomes. As a consequence, the objectives of physics learning are frequently not achieved as expected.

Students' learning success is reflected in their learning outcomes, which encompass cognitive, affective, and psychomotor domains. Learning outcomes are generally assessed through scores obtained from evaluations or tests conducted at the end of the learning process. Low learning outcomes indicate that students have not met the established Minimum Mastery Criterion (KKM) (Rahmi et al., 2020). Based on observations and interviews conducted at SMA Negeri 1 Kabila, it was found that many students experience difficulties in understanding physics concepts, resulting in most of them failing to achieve the KKM. One contributing factor to this condition is the dominance of teacher-centered instructional methods, particularly lecture-based teaching, which tends to make students passive and less motivated during the learning process.

To address these challenges, it is necessary to implement learning models that encourage active student engagement. One instructional model that is considered relevant is Discovery Learning, which emphasizes students' direct involvement in discovering concepts through stages such as observing, questioning, experimenting, analyzing, and drawing conclusions. This model enables students to construct their own knowledge independently and enhances their conceptual understanding of physics. Several studies have shown that the main strength of the Discovery Learning model lies in its ability to actively engage students in the learning process to discover and solve problems (Prasasti et al., 2019; Amelia & Sukma, 2021; Khoiroh et al., 2020).

The objectives of the Discovery Learning model include increasing students' active participation in acquiring and utilizing information, reducing their dependence on teachers as the sole source of knowledge, and fostering critical and analytical thinking skills (Astuti et al., 2018; Fitrhiyah et al., 2019; Shanthi & Maghfiroh, 2020). In the context of Newton's Laws, Discovery Learning provides students with opportunities to develop conceptual understanding through exploration, experimentation, and direct observation of motion phenomena. This approach is considered effective because it encourages students to think critically and to connect theoretical concepts with practical applications, although its implementation requires careful planning and optimal teacher guidance.

Based on these considerations, this study aims to examine the effect of the Discovery Learning model on students' learning outcomes in Newton's Laws at the senior high school level. It is expected that the application of this learning model can enhance students' cognitive abilities and learning creativity in physics education at the secondary school level.

METHOD

This study was conducted at SMA Negeri 1 Kabila, Bone Bolango Regency, Gorontalo Province, during the even semester of the 2024/2025 academic year. The research employed a quantitative approach using an experimental method aimed at examining the effect of the Discovery Learning model on students' learning outcomes in Newton's Laws. The experimental design applied in this study was the One Group Pretest–Posttest Design, involving one experimental class and two replication classes that received the same instructional treatment. The inclusion of replication classes was intended to strengthen the consistency and reliability of the findings. The learning activities were implemented over four meetings, which consisted of administering a pretest, applying the Discovery Learning model, and conducting a posttest to measure changes in students' learning outcomes.

The population of this study comprised all eleventh-grade students at SMA Negeri 1 Kabila, consisting of three classes with a total of 93 students. However, only 75 students participated fully in both the pretest and posttest and were therefore included in the data analysis. The sampling technique used was random sampling through a lottery system, resulting in class XI-5 being selected as the experimental class, while classes XI-3 and XI-4 served as replication classes (Sugiyono, 2017). This sampling approach was intended to provide equal opportunities for each class to be selected and to minimize sampling bias.

The independent variable in this study was the Discovery Learning instructional model, while the dependent variable was students' learning outcomes. The Discovery Learning model emphasizes active student involvement in discovering concepts through direct learning experiences, with the teacher acting as a facilitator who guides students throughout the learning process (Prasasti et al., 2019; Amelia & Sukma, 2021; Khoiroh et al., 2020). Through this model, students are encouraged to observe phenomena, formulate questions, conduct experiments, analyze data, and draw conclusions independently, thereby promoting deeper conceptual understanding. Students' learning outcomes were measured using an essay test designed to assess cognitive abilities across several levels, including understanding (C2), application (C3), analysis (C4), and evaluation (C5).

Prior to implementation, the learning instruments, including lesson plans and test items, were validated by two expert lecturers from the Department of Physics, Universitas Negeri Gorontalo. The validation process employed the instrument validation formula proposed by Widoyoko (2016), and the results indicated that all instruments were highly valid, with validation scores exceeding 80%. Reliability testing of the learning outcome instrument was conducted using the Cronbach's Alpha formula (Arikunto, 2018; Sugiyono, 2019), which demonstrated a high level of reliability, indicating that the instrument was consistent and suitable for measuring students' learning outcomes.

Data were collected through learning outcome tests administered as pretests and posttests. The pretest was used to measure students' initial abilities prior to the implementation of the Discovery Learning model, while the posttest was used to evaluate students' learning outcomes after the treatment. Data analysis was conducted using several statistical techniques. First, a normality test was performed using the Liliefors test to determine whether the data were normally distributed (Sudjana, 2005). Subsequently, a one-tailed t-test was applied to examine the significance of differences between pretest and posttest scores. In addition, N-Gain analysis was used to measure the magnitude of improvement in students' learning outcomes following the implementation of the Discovery Learning model (Hake, 1998).

The results of these analyses were expected to demonstrate a significant improvement in students' learning outcomes and to provide empirical evidence supporting the effectiveness of the Discovery Learning model in physics instruction. Ultimately, the findings of this study are intended to contribute to improving the quality of physics learning at the senior high school level (Astuti et al., 2018; Fitrhiyah et al., 2019; Shanthi & Maghfiroh, 2020).

RESULTS AND DISCUSSION

Learning Outcomes

In quantitative data analysis, an understanding of measures of central tendency and data dispersion is essential for determining the results of statistical tests. The mean score is used to describe the general tendency of respondents' data, while the standard deviation and variance indicate the degree of data dispersion around the mean. These measures play an important role in assessing data consistency and serve as the basis for hypothesis testing to determine whether there are significant effects or differences in the study.

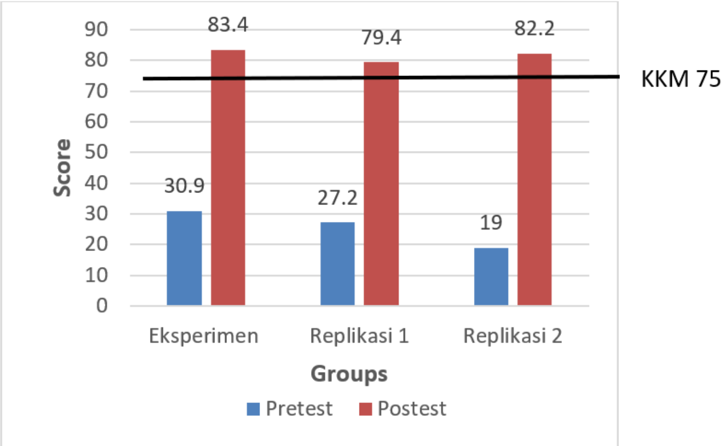

Figure 1. Improvement in students' learning outcomes in the experimental and replication classes

Based on Figure 1, an increase in learning outcome scores from pretest to posttest can be observed in the experimental class, replication class 1, and replication class 2. This improvement indicates that the implementation of the Discovery Learning model contributed positively to enhancing students' learning outcomes in Newton's Laws.

Analysis of data dispersion measures, including standard deviation and variance, also shows significant changes between pretest and posttest scores. The standard deviation and variance values for each class are presented in Table 1.

Table 1. Standard deviation and variance of students' learning outcomes

Class/Sample	Pretest SD	Posttest SD	Pretest Variance	Posttest Variance
Experimental (XI-5)	7.67	3.79	58.79	14.39
Replication 1 (XI-3)	11.00	4.51	121.03	20.35
Replication 2 (XI-4)	10.93	4.26	119.49	18.17

The data presented in Table 1 demonstrate a consistent reduction in the dispersion of students' learning outcomes from the pretest to the posttest across all classes. In the experimental class (XI-5), the standard deviation decreased from 7.67

in the pretest to 3.79 in the posttest, while the variance declined from 58.79 to 14.39, indicating a substantial narrowing of score distribution after the implementation of the learning model. A similar trend was observed in replication class 1 (XI-3), where the standard deviation dropped from 11.00 to 4.51 and the variance decreased markedly from 121.03 to 20.35. Likewise, in replication class 2 (XI-4), the standard deviation was reduced from 10.93 to 4.26, accompanied by a decrease in variance from 119.49 to 18.17. Overall, the decrease in standard deviation and variance from pretest to posttest across all classes indicates that students' learning outcomes became more homogeneous after the application of the Discovery Learning model, suggesting not only an improvement in average achievement but also a more even distribution of conceptual understanding among students.

Data Normality Test

The normality test was conducted to determine whether students' learning outcome data were normally distributed, which is a prerequisite for applying parametric statistical tests in subsequent analyses. The test was performed on posttest data from the experimental class, replication class 1, and replication class 2 using the Liliefors test at a significance level of α = 0.05 with the assistance of Microsoft Excel software. The results of the normality test are presented in Table 2.

Table 2. Results of the data normality test

Class	$L_{calculated}$	L_{table}	Description
Experimental	0.1006	0.18	Normal
Replication 1	0.1645	0.18	Normal
Replication 2	0.1647	0.18	Normal

As shown in Table 2, the $L_{calculated}$ values for all three classes are smaller than the critical L value ($L_{calculated} < L_{table}$) at α = 0.05. Therefore, the posttest data for both the experimental and replication classes are normally distributed. This result indicates that the assumptions for applying parametric statistical tests are fulfilled (Sudjana, 2005).

Hypothesis Testing

To determine whether there was a significant difference in posttest results after the implementation of the Discovery Learning model, a t-test analysis was conducted for each class. The results of the t-test are presented in Table 3.

Table 3. Results of hypothesis testing (t-test)

Class	$t_{calculated}$	t_{table}	Decision
Experimental	2.0595	1.711	H_0 Rejected
Replication 1	2.0595	1.711	H_0 Rejected
Replication 2	2.0595	1.711	H_0 Rejected

Based on Table 3, all sample classes show $t_{calculated}$ values greater than t_{table} at a significance level of α = 0.05. Thus, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, indicating a significant effect of the Discovery Learning model on students' learning outcomes. Furthermore, the average posttest scores exceeding the Minimum Mastery Criterion (KKM) of 75 demonstrate that this instructional model effectively improves students' conceptual understanding of Newton's Laws (Sudjana, 2005; Hake, 1998).

N-Gain Analysis

N-Gain analysis was conducted to determine the magnitude of improvement in students' learning outcomes between pretest and posttest.

Class Average N-Gain

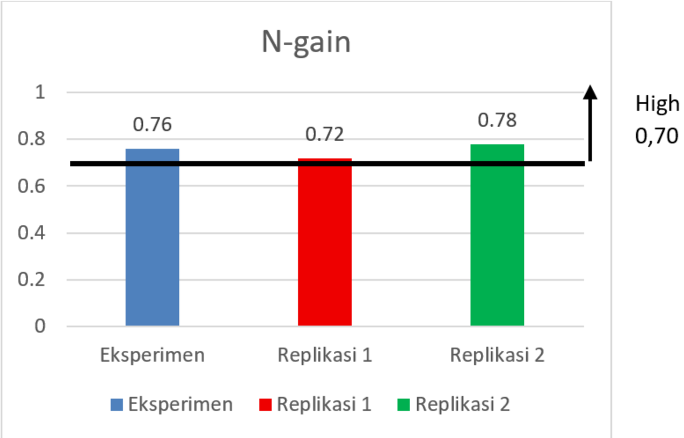

Figure 2. Course average normalized gain of the experimental and replication classes

Based on Figure 2, the N-Gain value for the experimental class was 0.76, while replication class 1 and replication class 2 achieved values of 0.72 and 0.78, respectively. All values fall within the high category according to Hake (1998), indicating that the Discovery Learning model is effective in improving students' learning outcomes in Newton's Laws.

Individual Student N-Gain

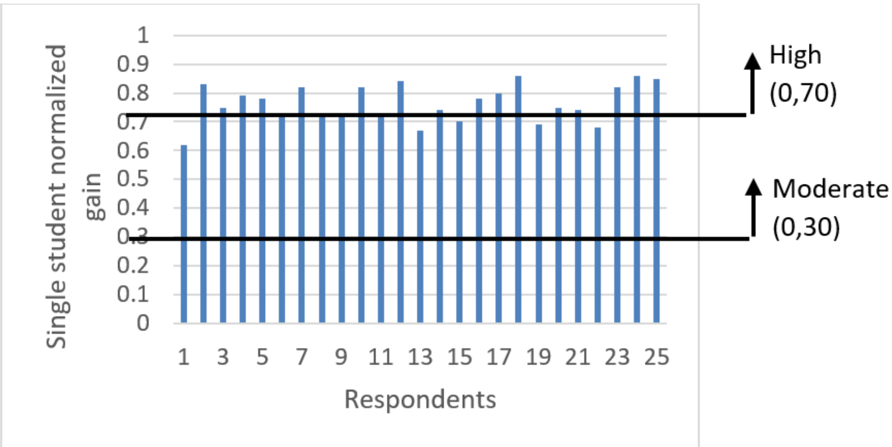

Figure 3. Single student normalized gain in the experimental class

Based on Figure 3, an improvement in cognitive learning outcomes was observed among students in the experimental class after the implementation of the Discovery Learning model. A total of 20 students were categorized as having high gains, while 5 students were classified in the medium category. This result indicates that the Discovery Learning model positively influences students' learning achievement quantitatively.

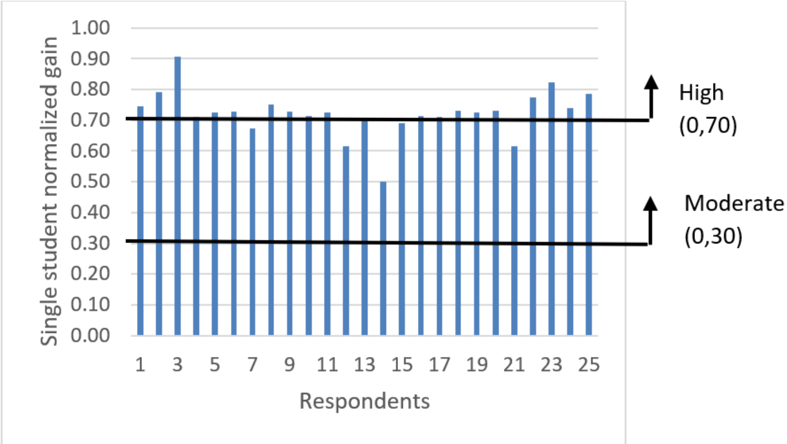

Figure 4. Single student normalized gain in replication class 1

As shown in Figure 4, all students in replication class 1 experienced improvements in cognitive learning outcomes following the application of the Discovery Learning model. Twenty students achieved high N-Gain values, while five students were in the medium category, indicating a positive quantitative impact of the learning model.

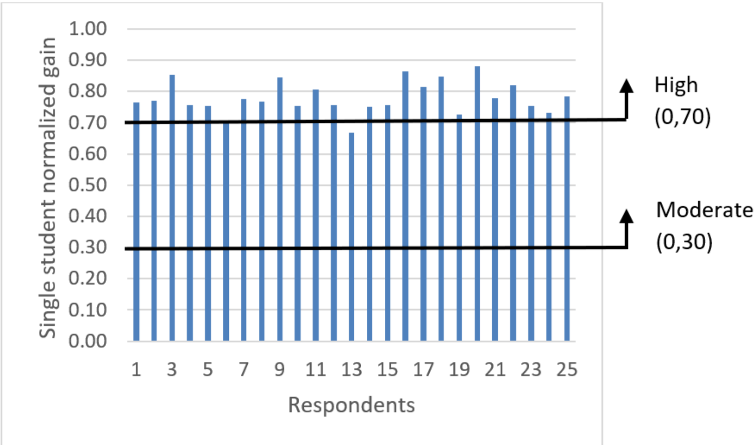

Figure 5. Single student normalized gain in replication class 2

Based on Figure 5, all students in replication class 2 demonstrated improved cognitive learning outcomes after the implementation of the Discovery Learning model. A total of 24 students were classified in the high N-Gain category, while one student was in the medium category. These findings further confirm the positive effect of the Discovery Learning model on students' cognitive learning outcomes.

This study examined the effect of the Discovery Learning model on students' learning outcomes in Newton's Laws by involving one experimental class and two replication classes. The use of replication classes constitutes an important methodological strength, as it allows the consistency of the findings to be evaluated across different learning groups receiving the same instructional treatment. Prior to the intervention, students' initial understanding was measured through a pretest, followed by the implementation of the Discovery Learning model and a posttest to assess learning gains. This sequence provides a clear depiction of changes in students' cognitive achievement attributable to the applied learning model.

During the implementation of Discovery Learning, the teacher acted as a facilitator who guided students through exploratory learning activities rather than serving as the primary source of information. Students were encouraged to observe physical phenomena, formulate questions, conduct experiments, analyze results, and draw conclusions independently. This instructional role aligns with the views of Trianto (2015), who emphasize that effective learning occurs when teachers guide students to actively construct knowledge rather than passively receive information. Such facilitative teaching supports student-centered learning and fosters deeper conceptual engagement, particularly in physics topics that require abstract reasoning.

The findings demonstrate a substantial increase in learning outcomes across all classes, as reflected by the marked improvement from pretest to posttest scores. The mean pretest scores were relatively low (30.9, 27.2, and 19.0), indicating limited prior understanding of Newton's Laws. After the application of the Discovery Learning model, the mean posttest scores increased significantly to 83.4, 79.4, and 82.2, respectively. This improvement suggests that Discovery Learning effectively supports students in developing a more comprehensive understanding of physics concepts. These results are consistent with the findings of Yuliati and Setyawan (2021), who reported that Discovery Learning enhances students' learning activities and conceptual comprehension in physics instruction.

The statistical analyses further reinforce the robustness of these findings. The Liliefors normality test indicated that the posttest data were normally distributed (Lcalculated < Ltable), confirming that students' learning outcomes were evenly distributed and suitable for parametric statistical analysis (Gunawan, 2020; Sarwono, 2022). Subsequent hypothesis testing using a one-tailed t-test revealed that tcalculated exceeded ttable in all classes, indicating a statistically significant effect of the Discovery Learning model on students' learning outcomes. This result aligns with the findings of Huda, Ramadhan, and Kurniawan (2021), who also reported significant learning gains following the implementation of Discovery Learning in science education.

Further evidence of the model's effectiveness is provided by the N-Gain analysis, which revealed high learning gains in all classes, with values of 0.76, 0.72, and 0.78. According to the classification proposed by Hake (1998), these values fall within the high category, indicating substantial improvement in students' conceptual understanding. These findings are in line with the study by Fitriani, Karyadi, and Ansori (2017), which demonstrated that Discovery Learning effectively enhances students' conceptual mastery. Moreover, the consistent N-Gain results across the experimental and replication classes strengthen the external validity of the study, as they indicate that the observed effects are not limited to a single class context (Sugiyanto & Nurhadi, 2023).

Overall, the findings of this study support previous research indicating that Discovery Learning is an effective instructional model for improving conceptual understanding and scientific thinking skills, particularly for abstract physics topics such as Newton's Laws (Rahmawati, 2020). By actively engaging students in the learning process, Discovery Learning helps bridge the gap between theoretical concepts and observable phenomena, thereby facilitating meaningful and lasting learning.

CONCLUSION

Based on the results of this study, it can be concluded that the Discovery Learning instructional model has a significant effect on students' learning outcomes in Newton's Laws. This conclusion is supported by the increase in mean scores from pretest to posttest across all classes. The experimental class achieved a mean posttest score of 83.4, while replication class 1 and replication class 2 obtained mean scores of 79.4 and 82.2, respectively, all of which exceeded the Minimum Mastery Criterion (KKM) of 75.

The results of the t-test analysis further indicate that the calculated t-values were greater than the critical t-values ($t_{calculated} > t_{table}$), demonstrating a statistically significant difference in students' learning outcomes before and after the implementation of the Discovery Learning model. In addition, the N-Gain values for all classes were above 0.70, which falls within the high category. These findings indicate that the Discovery Learning model is effective in substantially improving students' learning outcomes in physics, particularly in understanding Newton's Laws.

However, it should be noted that although a significant improvement in learning outcomes was observed, the results cannot be interpreted as a definitive causal relationship. This limitation arises from the research design, which did not include a control group for comparison. Therefore, the observed improvements should be understood as strong associative evidence of the effectiveness of the Discovery Learning model rather than absolute causal proof.

RECOMMENDATION

Based on the findings of this study, it is recommended that physics teachers implement the Discovery Learning model in teaching various physics topics to enhance students' learning outcomes and promote active participation in the learning process. The model's emphasis on student-centered exploration and conceptual discovery can contribute to more meaningful and engaging physics instruction.

Furthermore, future researchers are encouraged to expand the application of the Discovery Learning model to different contexts, subject matter, and research variables. Employing more rigorous experimental designs, such as including control groups or mixed-method approaches, may provide more comprehensive and in-depth insights into the effectiveness of Discovery Learning in science education.

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