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Analysis of Effectiveness of Discovery Learning Model in Science Learning Activities for Basic Students

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Abstract: Unlike other learning models, the Discovery Learning model emphasizes theoretical and practical in-depth material exploration, ensuring no learning objectives are overlooked. This differs from other student-centred learning (SCL) models, which grant full autonomy to students. The Discovery Learning model incorporates the role of lecturers as assistants, allowing students to build a strong foundational understanding of knowledge. This study investigates the effectiveness of the Discovery Learning model in science learning for students of the Madrasah Ibtidaiyah Teacher Education program at IAIN Sultan Amai Gorontalo. The research was conducted through four cycles, each consisting of the learning steps of stimulation, problem identification, data collection, data processing, verification, generalization, and reflection. The success of the learning activities was measured by improvements in learning outcomes, reflected in the scores of pre-tests conducted before implementing the learning model and post-tests conducted afterwards. The hypothesis was tested using the paired-sample test to determine the significance between pre-test and post-test scores in each cycle, followed by an effectiveness test using the N-gain test. The findings confirmed the hypothesis, as all cycles showed a t-value greater than the critical t-table value, indicating increased learning outcomes through the Discovery Learning model. This was also evident in the consistent improvement in the average scores between pre-tests and post-tests in each cycle. However, based on the N-gain test, the effectiveness of the learning model was found to be only 53.35%, which falls into the category of low effectiveness. This suggests a need for additional scientific literature and laboratory equipment within the scope of IAIN Sultan Amai Gorontalo.

Keywords: Discovery Learning; Learning Outcomes; N-Gain Test; Paired-Sample Test; Science Learning.

Introduction

According to Ki Hajar Dewantara, education is an effort to guide all the natural potentials within a child so that they, as individuals and members of society, can achieve the highest level of safety and happiness [1]. Ki Hajar Dewantara's perspective emphasizes that education is not merely the transfer of knowledge but also a process of guiding individuals to develop according to their innate potential. This approach has become increasingly relevant in modern education with the emergence of various student-centred teaching methods. Today's educational concepts focus on active learning, encouraging creativity, problem-solving, and adaptation to technological advancements and contemporary needs. Therefore, the question arises about how to educate students properly so that they not only understand the material but also can apply it in real life.

In education, the effectiveness of learning models becomes crucial in improving the quality of learning and student learning outcomes.

The main issue is whether these learning models are truly effective in enhancing students' understanding and skills in science education or if they create new obstacles in the teaching and learning process. One of the learning models that is widely implemented in response to the needs of the modern era is Discovery Learning. This model is believed to foster curiosity, develop critical thinking skills, and enhance conceptual understanding through independent exploration [2,3].

Several previous studies have examined the effectiveness of the Discovery Learning model at various educational levels. Fadillah et al. (2021) conducted a study on the effectiveness of the Discovery Learning model in science learning for Class 5B at SDN 19 Banyuasin 1 [4]. The study showed that the Discovery Learning model improved student learning outcomes. A similar finding was also obtained from a study conducted by Suari and Astawan (2021), who conducted research at SDN 3 and 5 Pulokulon [5], as well as Santoso and Airlanda (2022), who conducted research at SDN 1 Tetebatu [6]. At the secondary school level, several studies have shown that Discovery Learning can enhance conceptual understanding, critical thinking skills, and problem-solving abilities [7,8]. Discovery Learning enhances conceptual understanding because students receive information passively and actively engage in the process of exploration and concept discovery. By experiencing firsthand how a concept works, students can more easily connect new knowledge with their prior experiences. Discovery Learning also develops critical thinking skills by encouraging students to observe, analyze, evaluate, and draw conclusions based on the data they find. Regarding problem-solving, Discovery Learning trains students to find solutions through trial and error and think creatively when facing challenges.

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However, from the series of existing studies, all of them only conclude how the Discovery Learning model improves students' learning outcomes without ever addressing its effectiveness quantitatively. In addition, there has never been a study examining the effectiveness of the Discovery Learning model in science education at the university/institute/college level.

It is essential to conduct research at the institute level, especially for research subjects from the education student community. Future teachers need to understand effective learning models to apply them when they eventually enter the teaching profession. The assessment of whether they truly understand a particular learning model will naturally be reflected in their ability to engage with that model successfully.

This study aims to answer these questions by analyzing the effectiveness of the Discovery Learning model in science education for PGMI students at IAIN Sultan Amai Gorontalo. By examining students' learning outcomes, active engagement in the learning process, and potential challenges, this research is expected to provide deeper insights into implementing Discovery Learning in science education at the higher education level. In terms of novelty, this study contributes by examining the implementation of Discovery Learning in a context that has been rarely studied, specifically its application in higher education, particularly within the scope of PGMI. The impact of this research is expected to serve as a reference for lecturers in determining more effective teaching strategies and contribute to developing educational theory, particularly in implementing innovative learning models in higher education for science education.

Research Methods

This study falls into the category of experimental research, utilizing a quantitative approach by comparing students' pretest results conducted before the implementation of the treatment with their posttest results conducted after the treatment. In this study, a minimum of 15 students from the PGMI 3C class at IAIN Sultan Amai Gorontalo for the 2024–2025 academic year are involved in each cycle. This study consists of four cycles, each conducted over two sessions, each held weekly.

The study to test the effectiveness of the Discovery Learning model in science learning activities for the PGMI 3C class at IAIN Sultan Amai Gorontalo for the 2024–2025 academic year is conducted in cycles, involving four stages: planning, implementation, supporting data collection, and data analysis for concluding. The implementation of the Discovery Learning model consists of seven main steps: stimulation, problem identification, data collection, data processing, verification, generalization, and reflection. Stimulation is done by presenting relevant phenomena or problems, such as videos, images, guiding questions, or brief demonstrations, to spark students' curiosity. Problem identification is done by asking students to observe the phenomenon and then identify and formulate questions or issues that need further investigation. Data collection involves guiding students to seek information from various sources, such as books, journals, the internet, experiments, or interviews, to obtain data that supports problem-solving. Data processing is conducted by analyzing, categorizing, and interpreting the collected data to identify patterns or relationships useful for problem resolution. Verification is performed by testing hypotheses or analysis results through experiments, simulations, or group discussions to ensure the validity of the obtained information. Generalization involves drawing conclusions based on the verification results, allowing students to formulate general concepts or principles applicable to various situations. Reflection is carried out by asking students to evaluate the learning process, identify errors or shortcomings, and understand how the learned concepts can be applied in real-life [9][10][11][12]. The selected science topics for each cycle are presented in Table 1. These topics are chosen to ensure the representation of all key aspects of science learning.

Table 1. List of learning materials for each cycle

Cycle	Subject
1	Matter and Its Changes
2	Force and Energy
3	Earth and The Universe
4	Living Beings and Life

Data collection is conducted through tests administered before the learning activities (pre-test) and after the learning activities (post-test) in each cycle. Data is collected through documentation, interviews, and observations as supporting data.

The success of the learning activities is assessed based on students' learning outcomes, as reflected in the comparison of their pre-test and post-test scores in each cycle. Before the data can be used, an analysis of the validity and reliability of the test questions is conducted first [13]. Once the test questions are proven to be valid and reliable, the data is then tested for normal distribution using the Shapiro-Wilk method [14]. If the data is normally distributed, the Paired-Sample Test method is applied to determine whether the Discovery Learning model has a significant effect. The formula can be seen as:

$$t = \frac{\bar{D}}{SD/\sqrt{n}}$$

$\bar{D}$ is the mean difference between paired values (pre-test and post-test), SD is the standard deviation of the paired differences, and n is the number of sample pairs [15].

In this test, the calculated t-calculated value is then compared to the t-table value, which depends on the degrees of freedom determined by the sample size and the accepted margin of error. The Discovery Learning model is proven to affect students' learning outcomes if t-calculated > t-table. However, if t-calculated < t-table, then the hypothesis is rejected [15].

In principle, the hypothesis testing described above only demonstrates that implementing a learning model does indeed affect students' learning outcomes. While applying a learning model generally leads to positive effects—meaning an improvement in learning outcomes—we cannot ignore the possibility that its implementation might decrease students' performance. If this occurs, the hypothesis would still be proven, but contrary to expectations, it would indicate a decrease in learning outcomes. To ensure that a learning model's effect truly results in improved learning outcomes, it is necessary to measure the N-gain.

The N-gain test, or normalized gain test, is an assessment that provides a general overview of the improvement in learning scores before and after the implementation of a specific learning model. The N-gain test determines the increase in students' learning outcomes after a particular treatment by representing it in percentage form. Typically, this improvement is measured by comparing the pre-test and post-test scores obtained by the students. The formula for this calculation is shown as:

$$\text{N-gain} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximal score} - \text{pretest score}} \text{ x } 100\ \%$$

The detailed criteria for interpreting the effectiveness of N-gain can be seen in Table 2 as follows [16].

Table 2. N-gain test interpretation

N-gain Value (%)	Interpretation
<40	Ineffective
40-55	Less effective
56-75	Moderately effective
>76	Effective

Results and Discussion

Discovery Learning has significant advantages over other student-centred learning models, such as Problem-Based Learning (PBL), Project-Based Learning (PJBL), and Literacy, Orientation, Collaboration, and Reflection (LOC-R). One of the key aspects that distinguish Discovery Learning is its more systematic exploratory approach to building concepts independently [17]. In this model, students are encouraged to identify relationships between concepts and develop a deep understanding through a series of stages, including stimulation, problem identification, data collection, data processing, verification, generalization, and reflection. This advantage sets it apart from PBL, which focuses on solving contextual problems [18], and PJBL, which emphasizes projects as the final outcome [19]. Discovery Learning provides a balance between independent exploration and instructor guidance, enabling students not only to find solutions but also to understand the underlying principles [20].

The advantages of Discovery Learning are also evident in its flexibility across various fields of study and its ability to enhance critical and analytical thinking skills. Unlike Literacy, Orientation, Collaboration, and Reflection (LOC-R), which focuses on strengthening literacy, initial concept understanding, teamwork in problem-solving, and reflection on the learning process [21], Discovery Learning places greater emphasis on independent exploration in discovering concepts. This model gradually enables students to develop scientific reasoning skills, making it ideal for learning science, technology, and mathematics, which require a strong conceptual understanding. Moreover, compared to PJBL, which often emphasizes the outcome in the form of a project, Discovery Learning focuses more on the exploration process and deep conceptual understanding, ensuring that students acquire not only practical skills but also a solid theoretical foundation [20].

Furthermore, regarding effectiveness in increasing student engagement, Discovery Learning fosters higher intrinsic motivation and curiosity than other learning models. The independent discovery process, which is the core of Discovery Learning, provides a sense of ownership over the acquired knowledge, encouraging students to seek information and deepen their understanding continuously [22]. In PBL and PJBL, although students also play an active role, their primary focus may be more on completing specific tasks or projects rather than engaging in broader conceptual exploration. With a more systematic approach to helping students develop logical and structured thinking schemes, Discovery Learning enhances academic understanding and equips students with problem-solving skills applicable to various life and career contexts.

The research begins with the first cycle by assessing students' initial understanding of the science learning material "Matter and Its Changes" through a pre-test. After completing the pre-test, the Discovery Learning model is then implemented. The implementation of the learning model is divided into two lecture sessions, each conducted once a week. The learning steps, including stimulation, problem identification, data collection, and data processing, are carried out in the first session. Meanwhile, the subsequent steps—verification, generalization, and reflection—are conducted in the second session, which is finalized with a post-test to assess students' final understanding. The same process is repeated for the second, third, and fourth cycles, each covering different science learning materials, as listed in Table 1.

Before further analysis, validity and reliability tests were performed on the questions used. The validity test was carried out using the point-biserial correlation method, while the reliability test was conducted using the Kuder-Richardson 20 (KR-20) formula [13]. It was proven that all test instruments used were valid and reliable.

Next, a normality test was conducted. This step is crucial for determining the next procedure in data processing to test the hypothesis. Only normally distributed data can be analyzed using parametric tests, whereas non-normally distributed data can only be analyzed using non-parametric tests. The normality test was performed using the Shapiro-Wilk method in SPSS [14]. The test results confirmed that all data were normally distributed.

After testing the validity, reliability, and normality of the data, we proceed to the core analysis to test the hypothesis on whether the Discovery Learning model is effective in improving the science learning outcomes of students in PGMI 3C Class at IAIN Sultan Amai Gorontalo for the 2024/2025 academic year. Since the data is normally distributed, parametric testing can be applied. In this case, the Paired-Sample Test method is chosen due to its practicality in data processing. Table 3 presents the t-calculated values from the Paired-Sample Test for students in each cycle.

Table 3. t-calculated values from the Paired-Sample Test for students in each cycle

Cycle	t-calculated value
1	9.4936
2	11.3207
3	7.6383
4	23.0863

The data above uses a sample size of 15 for each case, resulting in a uniform degree of freedom of 14. For a two-tailed test with a degree of freedom of 14 and a 0.5% margin of error, the t-table value is 2.977 [23]. Among the four cycles, none have a t-calculated value lower than the t-table value, which means it can be concluded that the pre-test and post-test scores differ significantly across all four cycles.

This means that implementing the Discovery Learning model impacts students' learning outcomes, as reflected in their pre-test and post-test results. However, we have yet to determine how effectively this learning model improves student achievement. That is why the N-gain test is conducted. The N-gain values can be seen in Table 4.

Table 4. N-gain values from the N-gain Test for students in each cycle

Cycle	Average Pre-Test Score	Average Post-Test Score	N-Gain Value (%)	Interpretation
1	21.13	55.07	42.11	Less effective
2	21.73	74.6	66.39	Moderately effective
3	31.13	58.2	39.46	Ineffective
4	4.33	67	65.43	Moderately effective
Average			53.35	Less effective

Based on the data from Table 4, although the pre-test and post-test scores for each cycle differ significantly, the effectiveness of the Discovery Learning model in improving students' science learning outcomes remains insufficient. The highest effectiveness rate was 66.39% in the second cycle on the subject "Force and Energy," while the lowest was 39.46% in the third cycle on the subject "Earth and the Universe." The average N-gain was 53.35%, which falls into the "less effective" interpretation category.

Through direct observation, students were very enthusiastic about this learning model, as seen from their active engagement in asking the lecturer about concepts they did not fully understand. They actively engaged in discussions to find solutions to their problems independently. However, based on observations supplemented by additional data obtained during student interviews, this learning model was not without challenges. Nevertheless, the challenges that arose were external and unrelated to the teaching method. The main challenge was the lack of reference materials available to students. Most accessible resources were from the internet, whose reliability was still questionable. Adequate references for science subjects, both in quality and quantity, were not yet available in the IAIN Sultan Amai Gorontalo library. This issue was particularly significant because this learning model emphasizes active student participation in independently finding answers to questions arising from their curiosity. Consequently, the availability of adequate reference sources is crucial. Additionally, the lack of laboratory facilities was another challenge. Science learning inherently involves experiments, as students need to observe firsthand how scientific theories are applied. However, even basic equipment such as beakers or stirring rods was unavailable in the laboratory, forcing students to bring their makeshift tools—sometimes replacing beakers with drinking glasses or stirring rods with tea stirrers. These limitations contributed to the ineffectiveness of implementing the Discovery Learning model.

However, if we take a closer look at the increase in average scores from the pre-test to the post-test for each cycle in Table 4, it is not bad [7]The improvement is quite significant—from an initial range of 4.33 to 31.13, increasing to 55.07 to 74.6. This indicates that the Discovery Learning model has been fairly successful, although its effectiveness has not been evenly distributed among all students.

Conclusion

Based on the increase in average scores between the pre-test and post-test for each cycle, it can be concluded that the Discovery Learning model can improve students' learning outcomes. However, its effectiveness has not been evenly distributed among all students in the class, as indicated by the N-gain test results, which fall within the less effective range. In this regard, the researcher emphasizes the need to enrich the collection of science reference materials in the library and to enhance the availability of laboratory equipment at IAIN Sultan Amai Gorontalo.

Author’s Contribution

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