

Enhancing 4th-grade Students' Interest and Science Learning Outcomes through Differentiated Learning

A Quasi-Experimental Study at SD Muhammadiyah Kleco Kotagede, Yogyakarta

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ABSTRACT

The issue in science learning is the mismatch between the applied learning model and student characteristics, along with teachers' limited pedagogical abilities. This impacts students' interest and learning outcomes in science. This study aims to examine the effect of differentiated learning on students' interests and science learning outcomes. The research uses a quasi-experimental design with a two-group pretest-posttest control group approach. Data were collected through observations, a learning interest questionnaire, and a learning outcomes test. Simple random sampling was used, involving two classes: IV Tablig (28 students) and IV Amanah (29 students). Validity was tested using point biserial, and reliability was measured with KR-20. Data analysis included descriptive statistics and hypothesis testing using the Paired Sample t-test and Independent Sample t-test. Results showed that after the intervention, students' interest in science learning was in the moderate category (39.29%), and learning outcomes were also moderate (50%). The Paired Sample t-test indicated a significant improvement in interest and learning outcomes, while the Independent Sample t-test confirmed a significant difference between the experimental and control groups. Thus, differentiated learning has a significant effect on students' interest and science learning outcomes.

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Introduction

Science learning emphasizes lifelong education, adapting to the continuously evolving environment in line with human development. Owen et al. [1] states that science learning at every educational level should be interactive, inspiring, challenging, enjoyable, and motivating for students to actively participate. It should also provide sufficient space for creativity and independence according to students' interests, talents, and psychological and physical development. However, many issues arise in science learning at the elementary level. Lestari [2] notes that the applied learning models in science education are often ineffective, particularly in classroom management, leading to decreased student interest and academic performance. Maintaining student interest is crucial for achieving successful outcomes. Tiwow [3] states that interest helps students focus better on the material. Sugandi et al. [4] argue that a high level of interest facilitates students in achieving goals, while a lack of interest can result in disengagement and even resistance toward teachers.

In reality, students often experience low interest due to ineffective processes. Science instruction primarily relies on textbooks with minimal variation in teaching methods [5]. Classroom activities are limited to reading, writing, and listening to lectures, making the learning highly conventional. This passive approach leads to a lack of genuine interest, ultimately affecting student outcomes. According to Nabila et al. [6], Bloom's taxonomy categorizes outcomes into cognitive, psychomotor, and affective domains. The cognitive domain includes knowledge, comprehension, application, analysis, synthesis, and evaluation. The psychomotor domain involves skills, physical abilities, and intellectual capabilities, while the affective domain relates to attitudes, responses, values, and organization. Outcomes are influenced by both internal and external factors. Internal factors include cognitive abilities, motivation, interest, and readiness, while external factors include facilities, teacher competence, creativity, learning resources, methods, and family support [7].

Hotimah [8] emphasizes that teaching methods are techniques used in learning to achieve educational objectives. One effective model to enhance interest and outcomes is differentiated learning. Morgan [9] defines differentiated learning as an approach that recognizes and accommodates students' diverse interests, talents, and learning styles. At SD Muhammadiyah Kleco Kotagede (a private elementary school), science learning in 4th grade has been ineffective due to monotonous teaching methods that do not align with student characteristics. The process does not accommodate different learning styles, necessitating a shift in teaching methods. While several previous studies have explored the impact of differentiated learning on student interest and academic outcomes, most have focused on general classroom settings or secondary education levels, with limited research specifically targeting science learning in elementary schools using differentiated instruction combined

with active learning models such as Problem-Based Learning (PBL). This presents a significant research gap regarding how differentiated strategies can be applied in science education at the elementary level, particularly in the context of PBL to foster both interest and achievement.

Therefore, this study offers novelty in terms of research year, variables, and methodology. Differentiated learning remains a relatively new model in elementary science contexts, making its application an innovative approach to improve instructional quality. Based on these considerations, this study investigates how differentiated learning influences students' interest and science achievement, and is expected to provide a creative innovation in science learning.

Material and Methods

A. Research Design

This study employed an experimental design with two groups receiving different treatments. A quantitative research approach was used, as quantitative research generates new findings through statistical procedures or measurements, focusing on specific variables in human life [10]. The research design adopted was quasi-experimental, specifically a Two-Group Pretest-Posttest Control Group Design. Quasi-experimental research includes a control group but does not fully control external variables that may influence the experiment, as there is no random selection of participants. In this design, two groups—experimental and control—are selected randomly and given a pretest to assess initial conditions and determine any differences between them. The study involved 4th-grade students from Amanah, Tablig, Sidiq, and Fatonah classes at SD Muhammadiyah Kleco Kotagede. After random selection, Tablig was assigned to the experimental group, while Amanah was designated as the control group.

B. Learning Activities

The implementation of differentiation within PBL is based on Tomlinson's [11] framework, which includes differentiation in terms of content, process, product, and learning environment. In the experimental group that applied PBL, differentiation was implemented as follows:

- **Content:** Students were allowed to choose subtopics or specific problems related to the main theme that matched their interests and prior knowledge. This approach ensured that learners engaged with content that was meaningful and appropriately challenging for them.
- **Process:** During group discussions and problem-solving activities, students were encouraged to use varied strategies and resources based on their learning preferences. Teachers facilitated by offering scaffolding, guiding questions, or additional materials tailored to students' readiness levels.

- **Product:** Learners were given choices in how they demonstrated their understanding. For instance, some groups presented their findings through posters, while others created digital presentations or written reports, allowing them to express their learning in diverse formats.
- **Learning Environment:** The classroom was arranged to support flexible groupings and collaborative learning. Students had access to learning stations, resource materials, and quiet zones, enabling them to work in spaces that best supported their learning styles and social preferences.

These strategies were integrated into the PBL structure to ensure that students with varying needs, interests, and abilities could actively participate and benefit from the learning experience.

C. Variables

This study involved two main research variables. The dependent variables were students' interest and learning outcomes in science, while the independent variable was the application of differentiated learning using the PBL model. The experimental group received instruction through differentiated learning integrated with PBL, designed to accommodate students' varying interests, learning styles, and readiness levels. In contrast, the control group was taught using cooperative learning with the Numbered Heads Together (NHT) model, which emphasizes group collaboration and shared responsibility. Before the intervention, both groups were administered a learning interest questionnaire consisting of 12 items and a pretest containing 8 questions to assess their initial understanding. The teaching intervention was implemented in two cycles, each designed to actively engage students and address their individual needs. At the end of the intervention, a posttest was conducted to measure the impact of the respective learning models on students' interests and science achievement.

D. Instrument Validity and Reliability

Validity testing in this study was conducted using the Point Biserial formula at a 5% significance level to determine the appropriateness of each test item. The results showed that 12 out of 15 items on the learning interest questionnaire were valid, indicating a strong representation of the construct being measured. For the science assessments, 8 out of 15 questions on the pretest and 9 out of 15 questions on the posttest were deemed valid. In addition, reliability testing was carried out using the Kuder-Richardson Formula 20 (KR-20). The learning interest questionnaire demonstrated high reliability with an r_{11} value of 0.741. However, the reliability coefficients for the science pretest ($r_{11} = 0.379$) and posttest ($r_{11} = 0.353$) were relatively low, which can be attributed to the limited number of test items. Despite

the lower reliability scores, the instruments were still used to provide a general indication of students' understanding and progress throughout the intervention.

E. Data Analysis

Before conducting data analysis, a categorization test was performed using Microsoft Excel to classify students' scores into three categories: high, moderate, and low. This classification helped in interpreting the distribution of interest and learning outcome scores more effectively. Several statistical analyses were then carried out to evaluate the data. First, a descriptive analysis was conducted to summarize the overall trends and central tendencies in students' scores. Next, a normality test using the Kolmogorov-Smirnov method was applied to determine whether the data followed a normal distribution, with a significance value (p) greater than 0.05 indicating a normal distribution. To test the equality of variances, a homogeneity test was performed using Levene's test in SPSS; data were considered homogeneous if the significance value exceeded 0.05. Lastly, a Paired Sample t -test was used to test the hypotheses and measure changes in student interest and learning outcomes before and after the intervention. This test was applied to both the experimental group, which received differentiated learning with the PBL model, and the control group, which was taught using the NHT model.

Results

Based on the hypothesis test results using the Paired Sample t -test, the study aimed to determine the extent of students' interest and learning outcomes in science after the intervention in the experimental group and the control group at SD Muhammadiyah Kleco Kotagede. The results of the hypothesis test are presented in Table 1.

Table 1. Hypothesis Test Results (Paired Differences)

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pair 1 Interest Pretest - Interest Posttest	-31.257	18.307	3.460	-38.355	-24.158	-9.034	27	.000
Pair 2 Learning Outcome Pretest - Learning Outcome Posttest	-26.886	14.883	2.813	-32.657	-21.115	-9.559	27	.000

The Paired Sample t -test results indicate that both the pretest and post-test scores for students' interest and learning outcomes in the experimental group yielded p -values < 0.05 ($p = 0.000$), demonstrating a significant difference in student's interest and learning outcomes before and after the intervention.

Furthermore, an independent samples t-test was conducted to compare the post-test results of the experimental and control groups, as presented in Table 2.

Table 2. Independent Samples t-test Results

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
										Lower Upper
Interest Posttest	Equal variances assumed	0.411	0.524	2.998	55	0.004	9.33670	3.11473	3.09465	15.57875
	Equal variances not assumed	-	-	3.002	54.873	0.004	9.33670	3.11007	3.10365	15.56974
Learning Outcome Posttest	Equal variances assumed	3.861	0.054	4.141	55	0.000	13.70443	3.30951	7.07202	20.33684
	Equal variances not assumed	-	-	4.170	48.613	0.000	13.70443	3.28622	7.09920	20.30966

The Independent t-Test results show that the post-test scores for students' interest and learning outcomes in the experimental and control groups also yielded p -values < 0.05 , confirming a significant difference between the two groups. These findings indicate that the implementation of differentiated learning using the PBL model had a significant positive impact on student's interest and learning outcomes in science compared to the NHT method.

To complement the findings of statistical significance, Cohen's d was calculated to determine the magnitude of the differences observed in students' interest and learning outcomes between the experimental and control groups after the intervention. Effect size provides insight into the practical significance of the results, beyond p -values. Using the t -values and degrees of freedom from the independent samples t-test (Table 2), Cohen's d was computed using the formula.

Table 3. Effect Size using Cohen's d formula

Variable	t-value	df	Cohen's d	Effect Size
Interest Posttest	2.998	55	0.81	Large
Learning Outcome Posttest	4.141	55	1.12	Large

Based on Cohen's formula, these values represent large effect sizes, indicating that the use of differentiated instruction through the PBL model had a substantial positive impact on both students' interest and learning outcomes compared to the NHT method used in the control group. These findings reinforce the practical effectiveness of PBL with differentiation, not only yielding statistically significant improvements but also demonstrating strong educational relevance through large effect sizes.

The study implemented differentiated learning using the PBL model in the experimental group and cooperative learning using the NHT method in the control group. According to Tomlinson [11], differentiated learning integrates diverse learning styles to help students acquire information, generate ideas, and express knowledge. Kamal [12] identified four key aspects of differentiated learning: content, process, product, and learning environment.

The effectiveness of differentiated learning in the experimental group and the NHT method in the control group was assessed through pretest and posttest questionnaires measuring students' interest in learning science, consisting of 12 questions. The results for the experimental group showed that the pretest learning interest score was categorized as low (50.00), while the posttest score increased to a moderate category (39.29). The average pretest score was 54.71, increasing significantly to 86.56 after the intervention. These findings indicate that differentiated learning effectively enhanced students' interest in science. In contrast, the control group showed no improvement, with both pretest and post-test scores remaining in the low category (44.83), and the average score increasing only slightly from 55.74 to 76.63.

Similarly, the analysis of science learning outcomes demonstrated that differentiated learning was more effective than NHT. In the experimental group, the pretest learning outcome score was categorized as low (50.00) but improved to a moderate category (50.00) in the posttest. The average pretest score was 62.04, increasing to 88.93 after the intervention. In contrast, the control group saw minimal improvement, with pretest and post-test scores remaining in the low category (48.28 and 51.72, respectively), and the average score rising slightly from 65.35 to 75.22.

Overall, the findings suggest that differentiated learning using the PBL model had a significant positive impact on students' interest and learning outcomes, as evidenced by higher post-test scores in the experimental group. Meanwhile, the NHT method did not produce substantial improvements. These results indicate that differentiated learning is an effective instructional strategy for enhancing student engagement and academic performance in science.

Discussion

This study was conducted at SD Muhammadiyah Kleco Kotagede and aimed to analyze and describe the impact of differentiated learning on students' interest and learning outcomes in science for 4th-grade students, focusing on the topic "Energy Transformation and Potential Energy Transformation." The percentage data of students' interest and learning outcomes were used to describe and determine the influence of the differentiated learning approach applied in the study.

The implementation of differentiated learning using the PBL model had a significant effect on students' interest and learning outcomes in science. This was evident from the comparison of pretest and posttest results obtained from interest questionnaires and multiple-choice tests in the experimental group and the control group. The findings showed a significant increase in students' learning interest, categorized as "Moderate," and a notable improvement in learning outcomes within the same category.

The differences in students' interest and learning outcomes in science after implementing differentiated learning can be attributed to various factors related to differentiation strategies, students' characteristics, and learning context. According to Goyibova et al. [13], differentiated learning focuses on adjusting teaching instructions and materials to match students' understanding, learning styles, pace, interests, and needs. Teachers can apply various teaching strategies and methods, forming smaller learning groups based on students' differing comprehension levels and abilities. By tailoring teaching strategies to students' learning styles and characteristics, students are more engaged and interested in lessons because the instruction aligns with their needs and preferences, ultimately enhancing their interest and academic performance.

The differentiated learning approach in this study increased students' interest and learning outcomes in science, categorized as "Moderate." These changes reflected students' responses, learning achievements, and engagement levels in the learning process. Identifying the supporting and hindering factors in differentiated instruction can help teachers refine and enhance their teaching strategies to be more effective and beneficial for all students.

The differentiated learning approach applied in the experimental group significantly influenced students' interests and learning outcomes by adapting teaching methods to students' needs, interests, and learning styles. When teaching is tailored to students' individual preferences, they become more motivated and actively engaged in learning. Observations confirmed that the student's interest and learning outcomes improved significantly in the experimental group after the implementation of PBL-based differentiated learning, compared to the control group. The results showed a notable increase in students' interest and learning outcomes, categorized as "Moderate."

This finding aligns with Anik et al. [14], who states that differentiated learning helps tailor the teaching and learning process to meet each student's needs, enhancing their interest, learning profile, and readiness to achieve higher academic performance. Before implementing differentiated learning, a diagnostic assessment was conducted to identify students' capabilities, interests, and learning styles based on their characteristics. According to Wu et al. [15], diagnostic assessment consists of two types: non-cognitive assessment, which identifies students' backgrounds and prior competencies to help design personalized learning based on

their interests, talents, learning preferences, and everyday experiences; and cognitive assessment, which provides insights into students' fundamental knowledge and skills to guide the development of appropriate learning strategies. In this study, the diagnostic assessment served as the foundation for grouping students in the Tabligh class into three learning style categories: visual, auditory, and kinesthetic. Based on the results, visual learners were provided with visual teaching aids and Student Worksheets that guided them in creating concept maps to summarize key points from the lesson. Auditory learners received materials enriched with images, texts, and audio explanations. Their learning experience was further enhanced through music-based activities, and they were also assigned to compose song lyrics related to the science content. Kinesthetic learners engaged in hands-on activities, including an experiment involving spiral paper to demonstrate energy transformation. This differentiation strategy was designed to accommodate students' unique learning styles and optimize their engagement and comprehension during the science lessons.

This diagnostic assessment approach successfully captured students' interest. When students learn in ways that match their learning styles, they feel more engaged, pay greater attention, and actively participate. This engagement positively impacts their learning outcomes, leading to deeper retention of the material, improved comprehension, and enhanced application of knowledge. Student-centered learning provides students with greater freedom to engage in the learning process. In this approach, students do not merely listen to teacher explanations but actively participate in various learning activities that enhance their motivation, interest, and engagement. This active learning experience improves students' ability to remember material, understand concepts, and apply their learning. According to Sandria et al. [16], student-centered learning emphasizes active student participation rather than focusing solely on the teacher as the primary source of information.

In the differentiated learning approach, teachers ensure that students are prepared for learning by incorporating engaging activities. The study began with morning songs and chants, followed by ice-breaking activities such as rhythm-based claps to maintain student enthusiasm. These strategies enhanced students' attention and readiness, leading to better memory retention, comprehension, and real-life application of knowledge. This aligns with Pangestu [17], who states that learning readiness includes students' physical, mental, and emotional conditions, which significantly impact academic success.

A key characteristic of differentiated learning is student assessment. In this study, students' learning styles were classified into visual, auditory, and kinesthetic groups, and they were organized into study groups accordingly. This approach fostered a positive learning environment, encouraging students to enjoy the learning process, stay focused, engage in

learning activities, and participate actively in classroom interactions. Through this approach, students demonstrated better retention of learning materials, improved comprehension, and the ability to apply knowledge effectively. According to Lam et al. [18](2018: 34), student assessment helps evaluate whether a teacher's instructional approach effectively develops students' competencies. Assessment also monitors students' learning progress in cognitive, affective, and psychomotor aspects, guiding decisions on competency achievement and improvement strategies.

Another characteristic of differentiated learning is the adjustment of the learning environment. In this study, group-based learning activities were implemented to encourage student collaboration, foster enjoyment, and enhance active participation. This approach significantly impacted students' memory retention, understanding, and application of knowledge. According to Cayubit [19], the learning environment plays a crucial role in motivating students and influences their overall learning experience. A well-structured learning environment enhances student engagement and effectiveness in learning. It not only affects students' academic performance but also influences their cognitive and personal development.

Conclusion

The findings of this study confirm that differentiated learning using the PBL model effectively enhances students' interest and learning outcomes in science. By adapting teaching methods to students' learning styles, interests, and needs, students become more engaged, motivated, and actively involved in the learning process. The diagnostic assessment played a vital role in identifying students' learning styles, allowing for more personalized and effective learning strategies. Furthermore, the student-centered approach and interactive learning environment contributed to significant improvements in students' academic performance. These findings support the broader understanding that differentiated learning is a powerful instructional strategy that fosters higher student engagement and better learning outcomes.

Limitations

Despite the promising findings, this study has certain limitations that should be acknowledged. One notable limitation is the lack of consideration for external factors that may have influenced the results, such as teacher influence, classroom environment, and individual student motivation. These variables could have contributed to the observed improvements in students' interest and learning outcomes, and their potential effects were not controlled or measured in this study. Additionally, the research was conducted over a relatively short period, which limits the ability to assess the long-term impact of the intervention. Therefore, future research is recommended to adopt a longitudinal approach to evaluate the retention of science

concepts over time. This would provide deeper insights into the lasting effects of differentiated instruction using the PBL model and offer a more comprehensive understanding of its effectiveness in diverse educational settings.

Conflict of Interest

The authors confirm that they have no competing interests to disclose.

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