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The Influence of Differentiated Instruction through the Problem-Based Learning Model on Middle School Students' Achievement

Amalia Buntu[1*], Supriyatman[1], Syech Zainal[1]

[1] Program Studi Pendidikan IPA, Universitas Tadulako, Palu, Indonesia.

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Corresponding Author:
Amalia Buntu
amabuntu16@gmail.com

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Abstract: Effective learning must accommodate the unique needs of each learner. The combination of differentiated learning with PBL has not been widely revealed. This study aims to see the effect of differentiated learning through the Problem-Based Learning (PBL) model on student learning achievement. The research method used was a quasi-experiment using control and experimental classes. Data was collected through pretest and post-test. The control class used conventional learning, while the experimental class used differentiated learning with the PBL model. The results showed that using differentiated learning through the PBL model affected student learning achievement, with a sig value of 0.001 on the Mann-Whitney test. The average Normalized Gain (N Gain) of the control class was 0.32, while in the experimental class, it was 0.45. Both are in the medium category. In the control class, the N-Gain scores of individual students in the low, medium, and high categories were 52%, 40%, and 8%, respectively. The experimental class was 12%, 76%, and 12%, respectively. The improvement in student learning achievement in the experimental class is better than in the control class. Differentiated instruction provides access for students to be facilitated with their different needs, while with PBL, students can learn through contextualized problem-solving steps. Overall, it can be concluded that differentiated learning through the PBL model influences student learning achievement.

Keywords: Differentiated Instruction; Learning Style; Problem-Based Learning; Learning achievement.

Introduction

The quality of education at each school level should be improved from time to time, including at the junior high school level. Learning experiences at the junior secondary level are critical for socialization and interpersonal skill development (Accariya & Khalil, 2016). Junior high school is an important transition level between primary and higher education. Improving the quality of education at the junior secondary level can contribute to improving the quality of education in general.

One of the indicators of the quality of education at school is student learning achievement. Good learning achievement provides many positive things for student development. Some of these positives include higher levels of learning achievement, which contribute to increased student self-efficacy (Jehadus et al., 2022). Good learning achievement contributes to developing critical thinking, problem-solving, analysis skills (Stover et al., 2014), cognitive, interpersonal, and social skills (Kassa et al., 2024). In addition to this, good learning achievement can provide better career opportunities (Stover et al., 2014). Improving student learning

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achievement is important in education. Student learning achievement is the result of learning and is usually measured by class grades, assessments, and external learning outcome tests (Zeng, 2023). Good results in exams and assignments indicate understanding and mastery of the subject matter (Tong et al., 2022). On the other hand, although learning achievement is very important for students, there are still many low learning achievements found in various fields of study, such as mathematics (Fitrianti & Nur, 2018), English (Dewi et al., 2016), and science (Shamdas, 2023) Low learning achievement in science is also found at the research location. The scores obtained are still below the set standards. One of the causes of low learning achievement is the lack of development in the learning process (Artawan, 2023).

One way to develop learning is through differentiated learning. Differentiated learning is a learning process that accommodates the diverse characteristics of students (Sari, 2023). Differentiated learning proactively addresses differences in student learning needs (Smets & Struyven, 2018). Learning styles can be one of the teacher's references in implementing learning differentiation through content, process, and product differentiation. (Taylor, 2015). Each student's learning style is a unique way for each student to receive and process information (Bakar & Ali, 2018). Student learning styles can be divided into visual, audio, and kinesthetic (Deporter & Hernacki, 2005). Teachers can plan more effective learning by identifying and accommodating individual learning styles (Subban, 2006).

In addition to understanding the characteristics of individuals in the classroom, teachers also need to choose an effective learning model. One of these learning models is Problem-Based Learning (PBL). PBL is a teaching method that focuses on problem-solving as a way to acquire knowledge (Gillette, 2017). PBL can improve teamwork, the ability to listen, and the ability to defend opinions (Castañeda-Ayarza et al., 2019) and can facilitate students in gaining a deeper understanding of the material studied (Golightly & Raath, 2015). Through PBL, students' learning activities can be better in visual, oral, listening, writing, motor, and mental activities (Zakia et al., 2018).

Students' learning achievement is highly dependent on their learning methods, leading to teachers needing to adopt various teaching strategies (Saifi et al., 2024). One approach that can be applied is combining differentiated learning with PBL. This kind of research is important because Kurikulum Merdeka encourages every teacher to implement differentiated instruction in the teaching and learning process. The independent curriculum encourages an adaptive, inclusive, and tailored approach to student needs. (Maisyaroh et al., 2024). Teachers are given the freedom to implement learning that suits the needs of their students (Fatimah & Muamar, 2024). In addition to the differentiated instruction, the use of the PBL model, which has the potential to improve student learning outcomes, is one of the references for classroom learning models. Several studies have been conducted to see how differentiated learning affects learners (Yavuz, 2020), (Liou et al., 2023; Sapan & Mede, 2022) and how PBL affects learners (Syahidi et al., 2020), (Buyung & Alexon, 2022; Golightly & Raath, 2015; Shamdas, 2023; Halimah et al., 2023; Yuliana & Firmansah, 2018). Although PBL and differentiated learning have been widely reported to affect learning, differentiated learning through PBL is still very lacking in reports, especially in the city of Palu, in science subjects.

This study aims to describe differentiated learning through the PBL model's effect on students' learning achievement. This research can guide teachers in planning efficient learning with effective learning models without ignoring the needs of each student.

Method

This quantitative study uses a pretest-posttest nonequivalent control group design adapted from Cohen, L et al.. (2011). The flow of implementation of this research can be seen in Figure 1.

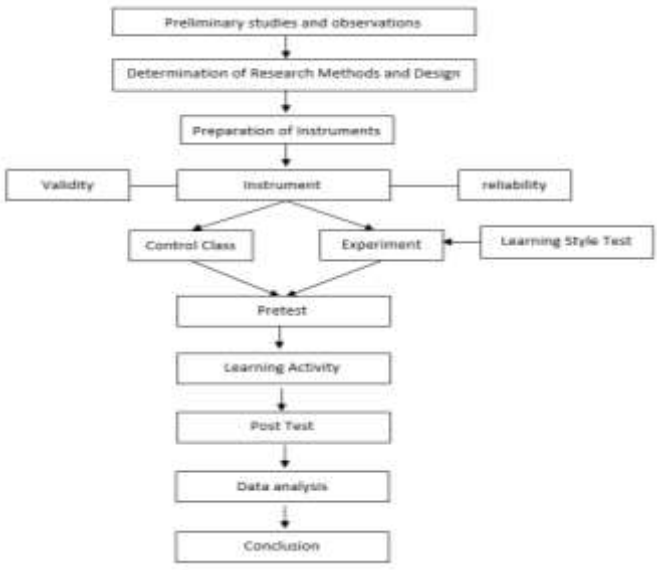

Figure 1. Research flow

This research was conducted in one of the junior high schools in Palu city in class VIII in science subjects. The study population was three classes with a population of 77 students. The samples used were two classes, each as a control and an experimental class, with 25 students per class. The research sample was obtained

through purposive sampling by looking at the suitability of the number of students in the class, subject matter, and student abilities.

The experimental class was taught with differentiated learning through the PBL model, while the control class was taught with conventional methods. Each class was given a pretest and post-test with a learning achievement instrument that had been tested for validity and reliability. The number of questions for the learning achievement instrument was 18 multiple-choice questions. Especially for the experimental class, a learning style test adapted from Victoria Chislett & Alan Chapman was given to determine the differentiation that would be carried out in learning.

Data from the pretest and post-test results were analyzed to obtain the difference in the improvement in student learning achievement. Furthermore, the data on the difference in the improvement in student learning achievement was tested for homogeneity and normality to determine the test used. In this study, the statistical test was the Mann-Whitney test to see the effect of differentiated learning through the PBL model on student learning achievement. The average Normalized gain (N-Gain) of control and experimental classes was calculated to determine each class's learning achievement improvement category. The categorization of student learning achievement improvement is referred to in Table 1 below:

Table 1. Normalized Gain Categories

Limitation	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

(Meltzer, 2002)

Result and Discussion

The main data of this research is in the form of pretest and post-test learning achievement test results in the control and experimental classes. The effect test is based on improving pre- and post-test learning achievement. The research results described are a descriptive analysis of learning achievement of control and experimental classes, normality and homogeneity tests of control and experimental classes improvement score, influence tests, and Normalized gain (N Gain). The results of N Gain are the percentage of the Individual N Gain category and the class average N gain. The descriptive analysis of the research results can be seen in Table 2.

Table 2. Descriptive Analysis Result

Variable	Pretest		Post Test		Improvement	
	Control	Experiment	Control	Experiment	Control	Experiment
Maximum	11	11	16	17	11	9
Minimum	2	1	5	6	0	2
SD	2.0	2.55	2.72	2.73	2.32	1.50
Total	140	138	240	270	100	132
Mean	5.6	5.25	9.6	10.80	4	5.8

At the pretest stage, it can be seen that both the control class and the experimental class have almost the same performance. Still, after being treated, it can be seen from the descriptive data that the experimental class had a better post-test. Data on the increase in learning achievement of both classes shows that the progress of the experimental class is better, but this needs to be proven by using statistical tests to compare the control and experimental classes. In the comparison test, data on learning achievement improvement is used.

Determining whether or not differentiated learning through the PBL model affects learning achievement is preceded by a basic assumption test, namely homogeneity and normality. The Homogeneity test can be seen in Table 3, and the Normality test results are in Table 4.

Table 3. Homogeneity Test Results of Learning Achievement Improvement

Levene Statistic	df1	df2	Sig.
1.434	1	48	.237

Table 4. Normality Test Results of Learning Achievement Improvement

		Shapiro-Wilk		
	Class	Statistic	df	Sig.
Improvement-Learning-achievement	Experiment	.942	25	.161
	Control	.889	25	.011

a. Lilliefors Significance Correction

Based on the results of the homogeneity test with the Levene Test, the significance value is 0.23 or greater than 0.05. These results indicate that the data is homogeneous. Furthermore, from the results of the data normality test, it is known that the significance value in the experimental class Shapiro-Wilk test is 0.16, This

value is greater than 0.05, so the data is said to be normally distributed. However, even though the data in the experimental class is normally distributed, the control class shows that the data is not normally distributed. This can be seen from the Shapiro-Wilk test value with a sig of 0.01, which is smaller than 0.05. Based on the normality test data of the two classes, the difference test between the control and experimental classes uses the Mann-Whitney test. The Mann-Whitney test results can be seen in Table 5.

Table 5. Mann-Whitney Test Results

	Improvement_Learning_achievement
Mann-Whitney U	147.500
Wilcoxon W	472.500
Z	-3.250
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Class

Table 5 shows that the Mann-Whitney test results have a significance of 0.001. This result is smaller than 0.05, so it can be said that differentiated learning through the PBL model affects student learning achievement. The experimental class learning model uses the PBL model. Differentiated learning is based on each student's learning style: Visual, Audio, and Kinesthetic. Students are divided into groups according to their learning styles. The assignments and products produced during the learning process refer to each learning style. The result of problem-solving can be a poster, audio explanation, or model.

In differentiated learning through the PBL model, students are ushered into learning by introducing problems regarding the material to be studied. The issues raised are contextual. By raising contextual problems for students, students become more interested and pay more attention to the material they will learn because they feel familiar with what will be learned, which will ultimately contribute to their learning achievement. This is supported by Aliyyah et al. (2020), who state that contextual-based learning will improve student learning outcomes.

After understanding the context of the problem, students are differentiated into groups of 3 - 4 members according to their learning style. Each group is directed to solve the problem in their own style. Visual students can illustrate their problem-solving through posters, kinesthetic students through props, and audio students through podcasts. When students are facilitated with their learning styles in the learning process, they become more involved and willing to participate in problem-solving tasks. In line with this, the findings of Wahyuni et al. (2023) show that implementing learning differentiation, including differentiation through learning styles, makes students more enthusiastic about implementing learning. During this process, the teacher guides and directs students in the learning process to ensure that each student is active in group and individual activities. With guidance from the teacher, students are encouraged to contribute their energy and ideas to problem-solving, which is supported by the findings of Chase et al. (2019), who state that teacher guidance during learning is very important and significantly impacts students' cognitive engagement.

During the learning process with PBL, students are directed to prepare and work on products that result from problem-solving as well as possible because these results will be presented. The demand to present the results of their work in front of classmates makes students more eager to do the tasks quickly and precisely, which is in line with the opinion of Tafonao (2018) that students' passion for learning will increase with the presentation that will be done.

The results of this study are in line with several separate studies on PBL, for example, found by Chen et al. (2017), PBL has a better effect on metacognitive awareness and learning achievement. Other research also shows that PBL positively affects interest, learning outcomes (Munawaroh et al., 2022), and student collaboration skills (Hidayati et al., 2023). Separate research on differentiated instruction also shows positive results. According to Krishan & Al-Rsa'I, (2023), differentiated instruction-oriented learning has a positive influence on students' motivation to learn. Furthermore, Rijal et al. (2025) found that differentiated learning could improve students' math learning achievement. After knowing that differentiated learning through the PBL model affects student learning achievement, the category of improvement in each class and individual is determined. The improvement category for each class is based on the average N Gain value of each class. The calculation of N Gain can be seen in Figure 2.

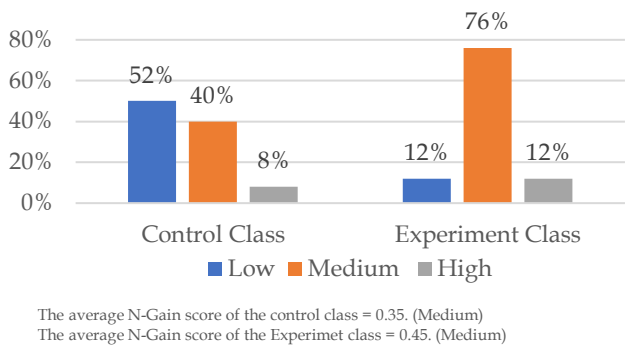

Figure 2. N Gain Test Results

Based on Figure 2, it can be seen that the performance of student learning achievement in the

experimental class is better. The experimental class reached 88% of students in the high and medium improvement category, and only 12% experienced low improvement. This is inversely proportional to the control class, where students who experienced low improvement were 52% more than the total number of students with high and medium improvement, namely 48%. The average N Gain of each class shows that the experimental class is also better at 0.45 while the control class is smaller at 0.32.

Although the N Gain value on the experimental class average is higher, the average increase in both classes is still in the medium category. This research is limited to learning style differentiation. Besides focusing on learning style differentiation, learning differentiation should be based on other aspects, such as student readiness and interest (Mavidou & Kakana, 2019). Differentiating on more aspects is expected to provide maximum improvement in the experimental class. Overall, this research shows that differentiated learning through the PBL model positively affects student learning achievement. This finding can be taken into consideration by teachers when designing effective learning.

Conclusion

In this study, it has been found that the use of differentiated instruction through the PBL model positively influences student learning achievement, which is proven through the Mann-Withey test results with a significance value of 0.001. The experimental class displayed better learning achievement with an average score increase of 5.8 points, while the control class had an average score increase of 4 points. The same can also be seen from the N Gain data per student, where the experimental class showed that 88% of students were in the medium to high improvement category, and only 55% were in this category in the control class. The average N Gain in the experimental class was 0.45, greater than the control class of 0.32. The category of improvement of the control and experimental classes is still in the same category range, namely Medium. Overall, differentiated instruction learning through the PBL model has a positive impact on student learning achievement. Through this learning formulation, individual students are accommodated for their learning needs and preferences through learning steps that accommodate contextual problem solving, mentoring and task completion.

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Author Contributions
Conceptualization, A.B., S.S. and S.Z.; Formal Analysis, A.B; Funding acquisition, A.B., S.S. and S.Z.; Investigation, A.B. and S.S.; Methodology, A.B. and S.Z.; Validation, S.S. and S.Z.; Writing Original Draft, A.B.; Writing review and editing, A.B., S.S. and S.Z. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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