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The Effectiveness of Differentiated Learning on Students' Mathematical Problem-Solving Abilities Based on Initial Abilities and Learning Styles

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ABSTRACT: This study aims to analyze the effectiveness of differentiated learning that considers students' initial abilities and learning styles in the learning process to develop students' mathematical problem-solving abilities. This study involved 48 7th grade junior high school students. The results of students' initial ability tests and learning style questionnaires were used to differentiate the learning process and content. Quantitative data were obtained by administering a mathematical problem-solving ability test and analyzed using descriptive statistics and ANOVA. The average score of students' mathematical problem-solving abilities after being given differentiated learning was 85.68, indicating that differentiated learning had a positive effect on students' mathematical problem-solving abilities. The results of the ANOVA test followed by the Tukey HSD test showed that each pair of groups of students' initial abilities differed significantly, thus, the initial ability category had a strong influence on students' problem-solving abilities. The results of the ANOVA test for the learning style category showed that differences in learning styles did not have a significant influence on the results of students' mathematical problem-solving abilities in the context of differentiated learning.

KEY WORDS: learning style, initial abilities, mathematical problem-solving abilities, differentiated learning

1. INTRODUCTION

Mathematical problem-solving ability is a skill that enables students to use mathematical activities to solve problems in mathematics, other sciences, and everyday life. Problem-solving ability is a crucial competency in mathematics, as it reflects students' critical, creative, and logical thinking skills when facing complex situations. However, various studies indicate that this ability remains low among the majority of junior high school students (Wahyuni et al., 2024; Siswanto & Meilasari, 2024; Herpeningtyas et al., 2025; Kafah et al., 2024; Awaji et al., 2025).

Mathematical problem-solving ability can be honed through an appropriate learning approach, one that considers the differences in student characteristics. Each student has different characteristics in terms of abilities, interests, learning styles, and family background. It is undeniable that student diversity leads to differences in how students understand learning materials. A uniform learning approach for all students in a class is insufficient to facilitate student learning (Valiandes, 2015; Lim, 2024). Currently, teachers are required to be innovative and creative in determining appropriate learning approaches to accommodate student differences.

Differentiated learning is an instructional approach that adapts learning content, processes, and products to students' abilities and learning styles. This approach is believed to improve learning effectiveness and learning outcomes, particularly in problem-solving skills (Pratiwi, 2024; Sofnidar et al., 2024). Pratiwi (2024) found that differentiated learning enhances problem-solving skills because students feel more comfortable and motivated with content tailored to their learning styles, resulting in significant improvements compared to conventional learning. Another study by Sofnidar et al., 2024 confirmed that implementing differentiated learning based on learning styles using the Project-Based Learning (PjBL) model can significantly improve junior high school students' mathematical problem-solving abilities.

Heterogeneous prior abilities in the classroom often pose a challenge for teachers in providing effective learning. Therefore, differentiated learning needs to accommodate differences in students' prior abilities to create an optimal learning process for all students. Research by Khoirunnisa et al. (2025) shows that differentiated learning using the Problem-Based Learning (PBL) model can significantly improve students' mathematical problem-solving abilities, by considering students' prior abilities as the basis for adjusting materials and learning strategies.

In addition to prior abilities, teachers also need to consider learning styles when implementing differentiated learning. Ikawati & Kowiyah (2021) found in their research that learning styles influence students' problem-solving abilities. Beishuizen et al. (1994) concluded that learning effectiveness depends on the match between learning styles and the type of learning support.

This study aims to examine how the implementation of differentiated learning, which takes into account both learning styles and prior abilities, can improve junior high school students' mathematical problem-solving abilities. This research is expected to make a significant contribution to the development of learning models that are more responsive and contextual to students' learning needs and serve as a reference for teachers in optimizing learning strategies.

II. METHOD

This research is an experimental study, using differentiated learning as the treatment. The treatment was administered to a sample of 48 students from two classes at a junior high school in Pontianak. The mathematics topic taught was Statistics for grade 7. This study will examine the effectiveness of differentiated learning on problem-solving skills in terms of students' initial abilities and learning styles.

Students' initial abilities were measured using a prerequisite ability test before entering the Statistics material. Based on the test results, students were categorized into three groups: those with complete understanding, those with partial understanding, and those with incomplete understanding. Learning styles were determined using a questionnaire, and students were then grouped into three learning style categories: auditory, visual, and kinesthetic. Table 1 presents the distribution of the sample based on their initial abilities and learning styles.

Table 1: Research Sample Based on Initial Ability and Learning Style

Categories		Learning Style			Total Students
		Auditory	Visual	Kinesthetic	
Initial Ability	Complete Understanding	2	6	3	11
	Partial Understanding	1	11	4	16
	Incomplete Understanding	6	8	7	21
Total Students		9	25	14	48

The research sample was given a treatment in the form of differentiated learning. After receiving the treatment, students completed a problem-solving ability test in the form of essay questions. Data was processed to determine the effectiveness of differentiated learning on problem-solving ability, based on students' initial abilities and learning styles.

III. RESULTS

The diversity of students in a classroom requires teachers to adapt appropriate learning strategies to accommodate student differences. This study attempts to accommodate student differences using a differentiated learning approach. Differentiated learning begins with an analysis of students' learning needs, which involves administering tests to identify students' initial abilities and questionnaires to identify students' learning styles. Learning differentiation is carried out by varying content and processes to accommodate students' initial abilities and learning styles.

Differentiated learning is conducted using a previously developed teaching module (Suryani et al., 2023). After the differentiated learning experience, students are then asked to complete a mathematical problem-solving test to measure the effect of differentiated learning on their mathematical problem-solving abilities. Table 2 presents data on students' overall problem-solving abilities and data grouped by initial abilities.

Table 2: Problem-Solving Ability Based on Initial Ability

Initial Ability Categories	N	Mean	SD	Min	Max
Complete Understanding	21	76,67	10,57	56,25	90
Partial Understanding	16	89,61	8,74	81,25	100
Incomplete Understanding	11	97,16	4,30	87,50	100
Total	48	85,68	12,18	56,25	100

Table 2 shows that differentiated learning impacted students' mathematical problem-solving abilities, with an overall average of 85.68. Table 2 also analyzed differences in students' problem-solving abilities based on their initial ability categories: not yet understood, partially understood, and fully understood. Descriptive statistics show that the average problem-solving ability score increased with students' initial understanding level. The not yet understood group averaged 76.67, the partially understood group

89.61, and the fully understood group 97.16. This indicates that better initial ability is followed by higher problem-solving abilities. The results of a one-way ANOVA showed that the difference in students' problem-solving abilities scores between the three groups was statistically significant ($F = 21.47$; $p < 0.001$). Further Tukey HSD tests revealed that each pair of groups differed significantly, including those with not yet understood and partially understood, those with not yet understood and fully understood, and those with partially understood and fully understood. Thus, the initial ability category has a strong influence on students' problem-solving abilities. The effect size calculation yielded a value of $\eta^2 = 0.488$, which is considered a large effect. This means that approximately 48.8% of the variation in problem-solving ability scores is influenced by students' initial abilities.

Differentiated learning in this study not only considers students' initial abilities but also their learning styles. The differentiation of content and processes attempted to accommodate students' differing learning styles to support their problem-solving abilities. Table 3 presents data on students' problem-solving abilities grouped by learning style.

Table 3: Problem-Solving Ability Based on Learning Style

Learning Style Categories	N	Mean	SD	Min	Max
Auditory	9	76,67	14,53	56.25	100
Kinesthetics	14	87,32	10,95	68.75	100
Visual	25	87,35	11,45	56.25	100

Table 3 analyzed the data to determine differences in students' problem-solving abilities after implementing differentiated learning based on learning style categories. Descriptive statistics show that students with an auditory learning style had an average score of 78.47, students with a kinesthetic learning style had an average score of 87.32, and students with a visual learning style had an average score of 87.35. Descriptively, the kinesthetic and visual learning groups scored higher than the auditory learning group. The results of the one-way ANOVA showed an $F(2, 45)$ value of 2.0235 with a p value of 0.1440. Therefore, at a significance level of 0.05, it can be concluded that there was no significant difference in problem-solving abilities between students with auditory, kinesthetic, or visual learning styles. This indicates that differences in learning styles did not significantly impact problem-solving outcomes in the given learning context.

The effectiveness measure was calculated using eta-squared (η^2), yielding a value of $\eta^2 = 0.0825$, which is categorized as a small effect size. This means that learning styles only explained approximately 8.25% of the variance in students' problem-solving ability scores. Therefore, it can be concluded that although descriptively there were differences in the average between groups, the contribution of learning styles to problem-solving ability in this study was relatively small.

IV. DISCUSSION

The effect size of the initial ability category has a strong influence on students' problem-solving abilities, calculation yielded a value of $\eta^2 = 0.488$, which is considered a large effect. These findings confirm that prior abilities play a crucial role in students' problemsolving success after participating in differentiated learning. Identifying prior abilities is the first step in differentiating learning so that students receive instruction appropriate to their current level (Abidin et al., 2024; Busri et al., 2023; Walter et al., 2025; Lee et al., 2021). Researchers then developed learning plans with differentiated content and processes to adapt to students' prior abilities.

The ability to plan learning is a key determinant of success in implementing differentiated learning (Mustafa et al., 2024; Estaiteyeh & DeCoito, 2023).

The average student problem-solving ability varied significantly at each prior ability level, but in general, the average problemsolving ability score for each prior ability level was good, above 75. This indicates that differentiated learning designed with differences in students' prior abilities in mind can support students' problem-solving abilities.

Overall, the analysis results indicate that differentiated learning produces relatively even problem-solving outcomes across learning style categories, and learning style is not a strong differentiating factor in students' problem-solving abilities. This finding indicates that the learning approach used is able to accommodate various learning styles quite well. Research by Ikawati & Kowiyah (2021) shows that learning that takes students' learning styles into account can improve their problem-solving abilities. Similarly, research by Pratiwi (2024) shows that content differentiation that adapts to learning styles makes students feel comfortable in learning, thereby improving their problem-solving abilities.

V. CONCLUSION

This study tested the effectiveness of using differentiated learning to support students' mathematical problem-solving abilities. Descriptive statistical analysis showed that differentiated learning had a positive impact on students' mathematical problem-solving abilities. This was demonstrated by the average score of 85.68 for students' mathematical problem-solving abilities after receiving differentiated learning.

The results of the inferential statistical analysis indicated that students' prior abilities had a strong influence on their mathematical problem-solving abilities. The effect size calculation revealed that 48.8% of the variation in problem-solving ability scores was influenced by students' prior abilities. The higher the students' prior abilities, the better their problem-solving ability scores. Learning styles, on the other hand, accounted for only 8.25% of the variance in students' problem-solving ability scores. This demonstrates that learning that considers students' learning styles allows students to learn comfortably and accommodates differences in learning styles.

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