

The Effect of Differentiated Learning on the Conceptual Understanding and Arithmetic Skills of Fifth Grade Students of SD Negeri 6 Sangia Wambulu

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Abstract

The low conceptual understanding and mathematical calculation skills of elementary school students remain a challenge in improving the quality of learning. Uniform and procedural-oriented learning has not fully accommodated differences in student learning readiness, resulting in students having difficulty understanding the meaning of concepts and lacking the skills to perform arithmetic operations accurately and confidently. Although differentiated learning has been widely studied theoretically, empirical evidence regarding the effectiveness of differentiated learning-based learning readiness processes on these two aspects is still limited. This study aims to analyze the effect of differentiated learning on conceptual understanding and mathematical calculation skills of fifth-grade students. The study used a quantitative approach with a quasi-experimental design in the form of a nonequivalent control group design. The research subjects were 27 students, consisting of 16 students from the experimental class and 11 students from the control class. The research instruments included a conceptual understanding test and a mathematical skills test. Data were analyzed using normality tests, homogeneity tests, paired sample t-tests, Wilcoxon tests, and Mann-Whitney tests at a significance level of 0.05. The results showed that differentiated learning significantly influenced students' conceptual understanding and mathematical skills ($p < 0.05$). In addition, there was a positive and significant relationship between conceptual understanding and mathematical skills. These findings indicate that process differentiation based on learning readiness is effective in strengthening conceptual construction while increasing elementary school students' mathematical fluency and accuracy.

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1. INTRODUCTION

Mathematics is a fundamental subject that plays a crucial role in developing elementary school students' logical, analytical, systematic, and critical thinking skills. However, the reality on the ground shows that Indonesian students' numeracy achievement still faces serious challenges. National assessment reports indicate that students' numeracy skills remain low, particularly in conceptual understanding and numeracy skills (Irwan & Masrul, 2023). This condition aligns with the findings of a preliminary study conducted by researchers in October–November 2024 in Sangia Wambulu District, Central Buton

Regency, which showed that most fifth-grade students had difficulty understanding basic mathematical concepts and lacked adequate numeracy fluency.

Observations at Sangia Wambulu 6 Public Elementary School show that more than 60% of students scored below the Minimum Completion Criteria (KKM) in the final assessment of the odd semester of the 2024/2025 academic year. The learning process is still dominated by conventional, teacher-centered methods, with an emphasis on procedures and memorization, rather than on conceptual understanding. As a result, students tend to be passive, less engaged in discussions, and experience difficulties when faced with problems that require reasoning. Poor conceptual understanding directly impacts weak arithmetic skills, as students do not understand the relationships between concepts that form the basis of mathematical operations.

Theoretically, conceptual understanding is the cognitive ability to restate concepts, classify objects, provide examples and non-examples, represent them in various forms, and apply concepts in problem-solving (Ramadhina et al., 2021). This indicator is also emphasized in the Director General of Elementary and Secondary Education Regulation No. 506/C/Kep/PP/2004. Meanwhile, numeracy skills include accuracy and fluency in performing basic mathematical operations (Komariah & Pebriyanti, 2023). These two aspects are the main foundations of numeracy that elementary school students must master.

One relevant approach to addressing these issues is differentiated learning. Tomlinson (2000) defines differentiated learning as a systematic effort to adapt learning content, processes, and products based on students' readiness, interests, and learning profiles. This approach aligns with Ki Hajar Dewantara's educational philosophy, which emphasizes education as a process of guiding children's natural development according to their individual potential (Herwina, 2021). In the context of the Independent Curriculum, differentiated learning is a key strategy for creating student-centered learning that is flexible to diversity (Aprima & Sari, 2022).

Several previous studies have demonstrated the effectiveness of differentiated learning in improving mathematical skills. These include significant improvements in mathematical problem-solving skills (Diokta Ardani et al., 2024), improved conceptual understanding through learning style-based differentiation (Irnelia et al., 2025), and improved student literacy and numeracy through differentiation strategies (Fitriyana et al., 2024). However, most of these studies have not simultaneously examined conceptual understanding and numeracy skills as two essential indicators of numeracy, particularly with a focus on process differentiation.

Based on the empirical urgency and research gaps, this study aims to: (1) analyze the influence of differentiated learning on fifth-grade students' understanding of mathematical concepts; (2) analyze its influence on numeracy skills; and (3) measure the magnitude of the influence of differentiated learning on both aspects simultaneously. This research is expected to provide an empirical contribution in strengthening adaptive, inclusive mathematics learning practices that are aligned with the implementation of the Independent Curriculum in elementary schools.

2. METHOD

This study used a quantitative approach with a quasi-experimental nonequivalent control group design. This design was chosen because the subjects were not randomly selected, but rather compared two equivalent groups. The experimental group received differentiated learning (process differentiation), while the control group received

conventional learning. Both groups were given pretests and posttests to measure changes in conceptual understanding.

The research sample was fifth-grade students of SD Negeri 6 Sangia Wambulu as the experimental class and fifth-grade students of SD Negeri 3 Sangia Wambulu as the control class. Subjects were selected purposively by considering the equivalence of the curriculum, grade level, and relatively homogeneous student learning characteristics.

Data collection instruments included a descriptive conceptual understanding test based on Ministry of National Education indicators (restating concepts, classification, representation, and application), as well as a numeracy skills test to measure the accuracy and fluency of basic mathematical operations. In addition, questionnaires and observation sheets were used to monitor the implementation of differentiated learning. Instrument validity and reliability tests were conducted before the study. Data were analyzed using prerequisite tests (normality and homogeneity) and hypothesis testing, *paired sample t-test*, *Wilcoxon signed rank test*, and *Mann-Whitney test*, as well as correlation tests to measure the relationship between variables.

3. RESULTS AND DUSCISION

1. The Effect of Differentiated Learning on Understanding Mathematical Concepts

1.1. Description of Research Results on Concept Understanding

This study aims to determine the effect of differentiated learning on fifth-grade students' understanding of mathematical concepts. Measurements were conducted using pretests and posttests in the experimental and control classes. Before the treatment was administered, both groups had relatively comparable initial abilities. This is evident from the average pretest scores, which showed no significant difference.

Table 1. Descriptive Statistics of Concept Understanding of Experimental Class

Test Types	N	Rate-rate	Standard Deviation
Pretest	16	36,09	9,49
Posttest	16	65,16	15,74

Table 2. Descriptive Statistics of Control Class Concept Understanding

Test Types	N	Rate-rate	Standard Deviation
Pretest	11	22,27	10,57
Posttest	11	40,91	9,03

1.2. Prerequisite Analysis Test

Before conducting the hypothesis test, the data were tested for normality and homogeneity to ensure the suitability of using parametric tests.

Table 3. Results of the Concept Understanding Normality Test

Variables	Class	Say.	Information
Concept Understanding Pretest	Control	0,225 > 0,05	Normal
	Experiment	0,060 > 0,05	Normal
Posttest	Control	0,161 > 0,05	Normal

Concept Understanding	Experiment	0,328 > 0,05	Normal
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Table 4. Results of the Homogeneity of Variance Test

Variables	Levene Statistic (F)	Say.	Information
Concept Understanding Posttest	2,383	0,135	Homogeneous

1.3. Hypothesis Testing

To determine the effect of differentiated learning on students' conceptual understanding, a paired sample t-test was conducted.

Table 5. Results of the Paired Sample t-Test for Concept Understanding

Test Types	N	Rate-rate	t count	Sig. (2-tailed)
Pretest	27	30,46	-10,086	0,000
Posttest	27	55,28		

2. The Effect of Differentiated Learning on Numeracy Skills

2.1. Description of Numeracy Skills Data

Table 6. Descriptive Statistics of Experimental Class's Numeracy Skills

Test Types	N	Mean Rank	Information
Pretest	16	41,88	Tends to be Low
Posttest	16	86,25	Experienced a Significant Improvement

Table 7. Descriptive Statistics of Control Class Numeracy Skills

Test Types	N	Mean Rank	Information
Pretest	11	40,00	Tends to be Low
Posttest	11	59,09	There has been an increase but it is not yet significant

2.2. Nonparametric Test

The numeracy skills data were not completely normal, so the Wilcoxon and Mann-Whitney tests were used.

Table 8 Results of the Wilcoxon Signed Rank Test

Statistics	Mark
WITH	-3,468
Sig. (2-tailed)	0,001

Table 9 Mann-Whitney Test Results

Class	N	Mean Rank
Experiment	16	17,06
Control	11	9,55

2.3. Correlation Test

Table 10 Results of the Correlation Test of Concept Understanding and Calculation Skills

Variables	Correlation Coefficient (r)	Say.
Conceptual Understanding Numeracy Skills	0,635	0,000

Discussion

1. The Effect of Differentiated Learning on Concept Understanding

The results of the study indicate that differentiated learning significantly impacts the improvement of fifth-grade students' understanding of mathematical concepts. This is demonstrated by the significant differences between pretest and posttest scores, as well as the significant differences between the experimental and control groups. This, coupled with the large effect size, demonstrates that the differentiated learning approach is able to help students develop deeper conceptual understanding.

These findings align with the theory of differentiated learning, which states that conceptual understanding will develop optimally when the learning process is tailored to students' learning readiness, interests, and learning profiles. In differentiated learning, students are not treated uniformly but are facilitated to learn according to their individual needs and abilities. Adapting the learning process allows students to construct knowledge in a gradual and meaningful way, rather than simply following procedures or memorizing problem-solving steps, thus helping them develop a deeper understanding of concepts (Malehere & Listiani, 2024).

Conceptually, understanding mathematical concepts requires students to be able to restate concepts, classify objects, and apply concepts in problem-solving. Differentiated learning provides students with the opportunity to achieve these indicators through varied learning activities, flexible grouping, and the provision of *scaffolding* that corresponds to the students' level of readiness. This explains why students in the experimental class showed a higher increase in conceptual understanding compared to the control class using conventional learning.

Theoretically, these results are in line with Tomlison's view, which emphasizes that differentiated learning enables students to learn in the zone of proximal development (*Zone of Proximal Development/ ZPD*) by Vygotsky. In this zone, students can optimally construct new concepts through scaffolding from teachers and peers. When students gain learning experiences appropriate to their level of readiness, the process of assimilation and accommodation of mathematical concepts can proceed optimally (Wibowo *et al.*, 2025). In the context of this research, differentiation of the learning process provides opportunities for students to understand mathematical concepts through varied activities, both individually and in groups, so that concepts are not only memorized, but also provide space for students to construct meaningful understanding of concepts.

From the constructivist perspective pioneered by Jean Piaget, conceptual understanding is formed when students actively relate new knowledge to their existing cognitive structures. Differentiated learning facilitates this process of assimilation and accommodation by providing a variety of representations, discussions, and learning experiences appropriate to the students' level of thinking

development (Rizkiet *al*, 2025). This supports the indicators of understanding mathematical concepts as formulated by the Ministry of Education and Culture, namely the ability to restate concepts, classify objects, provide examples and non-examples of a concept that has been studied, present concepts in various representations, and apply concepts in problem solving (Sengkey *et al*, 2023).

Improved understanding of mathematical concepts also demonstrates that differentiated learning can overcome the weaknesses of conventional learning, which tends to emphasize procedures without meaning. With differentiation, students are not forced to follow a uniform learning method but are instead facilitated to build concepts through representations, discussions, and exercises that are appropriate to their abilities. This supports indicators of mathematical conceptual understanding, such as the ability to restate concepts, classify objects, and apply concepts in problem-solving.

The findings of this study strengthen the results of previous research, that differentiated learning based on learning readiness significantly improves elementary school students' mathematical problem-solving abilities (Diokta Ardani *et al.*, 2024). In addition, differentiation based on learning styles has a positive impact on understanding mathematical concepts (Irnelia *et al.*, 2025). There are also research results showing that differentiated learning strategies have a significant influence on improving students' numeracy, which includes aspects of elementary school students' conceptual understanding. (Fitriyana *et al.*, 2024). The similarity of these findings strengthens the researcher's position that process differentiation is an effective strategy in building deeper conceptual understanding in students.

Based on the research results, empirically differentiated learning has been proven to have a significant effect on improving the understanding of mathematical concepts of fifth-grade students. This is indicated by the results of the Paired Sample t-test, which shows a significant difference between the pretest and posttest scores of conceptual understandings in the experimental class, with a significance value of Sig. (2-tailed) $0.000 < 0.05$. In addition, the results of the comparison of posttest scores of conceptual understanding show that the average score of students in the experimental class is higher than that of the control class, which indicates that the application of differentiated learning is more effective than conventional learning. The results of this study are in line with the theory of differentiated learning proposed by Carol Ann Tomlison, which states that differentiated learning emphasizes adjusting content, processes, and learning products based on readiness, interests, and learning profiles according to needs and abilities, so that mathematical concepts can be understood more meaningfully (Sadat & Harisuddin, 2024).

Theoretically, it can be concluded that differentiated learning plays an important role in increasing the occurrence of more intense cognitive interactions, providing appropriate scaffolding, and strengthening the conceptual representation of mathematical concepts, which is the main foundation for the development of mathematical abilities at the next level.

2. The Effect of Differentiated Learning on Numeracy Skills

The results of the study indicate that differentiated learning has a significant effect on improving fifth-grade students' mathematical calculation skills. This is evidenced by the results of the Wilcoxon and Mann-Whitney tests, which show differences between students' mathematical calculation skills before and after

differentiated learning. In addition, the difference in calculation skills between the experimental class and the control class also shows significant results with a value of Rank-Biserial Correlation. A value of 0.67 is in the strong category, which pedagogically indicates that differentiated learning significantly contributes to improving students' accuracy and fluency in performing arithmetic operations. This finding confirms that differentiated learning significantly contributes to improving arithmetic skills.

This finding can be explained by the characteristics of differentiated learning, which emphasizes an adaptive learning process. In the context of numeracy skills, students require practice appropriate to their ability level to develop speed and accuracy in performing arithmetic operations. In differentiated learning, students with lower abilities can receive intensive support, while students with higher abilities can be given appropriate challenges to develop their skills (Indrawatiningsih et al, 2024).

Theoretically, skills are inseparable from understanding the underlying concepts. Differentiated learning trains students' numeracy skills through activities tailored to their ability levels. Lower-ability students receive more scaffolding and incremental practice, while higher-ability students receive challenges that encourage accuracy and speed in their calculations.

This approach aligns with constructivist learning theory, which emphasizes the importance of active student involvement in building knowledge and skills. In this study, process differentiation provides students with contextual and meaningful numeracy practice, ensuring that the skills acquired are not mechanical but integrated with conceptual understanding.

These results are also relevant to the objectives of mathematics learning in elementary schools, which emphasize mastery of basic skills as a foundation for advanced mathematics learning. The results of this study are also consistent with findings that suggest that adaptive learning that adapts to differences in student abilities significantly improves basic arithmetic skills (Komariah & Pebriyanti, 2023). Furthermore, differentiated learning in the Independent Curriculum contributes to improved numeracy, particularly in the aspect of arithmetic fluency (Fitriyana & Dewi Nirmala, 2024). The results showed that students who participated in differentiated learning experienced improved numeracy skills, as indicated by a significant difference in pretest and posttest scores, with a significance value of $p = 0.024 < 0.05$, as well as an increase in the average numeracy score compared to conventional learning. These findings indicate that differentiated learning processes can train students in arithmetic operations according to their level of readiness and learning pace.

These findings are in line with the results of this study, which showed that students' numeracy skills in the experimental class experienced a significant increase after the implementation of differentiated learning. This is evidenced by the results of the Wilcoxon Signed Rank Test, which showed a significance value of $\text{Sig. (2-tailed)} = 0.001 < 0.05$, which indicates a significant difference between the pretest and posttest scores of students' numeracy skills. In addition, the results of the Mann-Whitney test showed a significant difference in numeracy skills between the experimental class and the control class, with a significance value of $\text{sig. (2-tailed)} = 0.014 < 0.05$. These data confirm that differentiated learning not only improves conceptual understanding but also has a direct impact on students' numeracy skills.

Thus, differentiated learning can be seen as an effective approach to strengthening students' numeracy, especially in the aspect of counting skills.

3. The Effect of Differentiated Learning on Concept Understanding and Numeracy Skills

Based on the results of the Pearson correlation test between the posttest value of conceptual understanding and the posttest value of mathematical skills, a correlation coefficient of $r = 0.635$ was obtained with a significance value of $p = 0.000$ ($p < 0.01$) in a sample of $N = 27$. These results indicate a strong and significant relationship between conceptual understanding and mathematical arithmetic skills of fifth-grade students. This finding indicates that these two abilities develop in an interrelated manner, where students who have better conceptual understanding tend to have higher arithmetic skills and vice versa.

Furthermore, the results of the paired-sample t-test on conceptual understanding showed a significant increase between the pretest and posttest scores. The average pretest conceptual understanding score was 30.46, while the average posttest score increased to 55.28. The average difference was significant with a t-value of -10.086 and p-value of 0.000 ($p < 0.05$), and was supported by Cohen's d value of 1.63, indicating a very large effect of differentiated learning on students' mathematical conceptual understanding.

For math skills, the Wilcoxon Signed Rank Test results showed a significant difference between pretest and posttest scores with a Z value of -3.468 and $p = 0.001$ ($p < 0.05$). A total of 20 students experienced an increase, 4 students experienced a decrease, and 3 students had the same score. The Rank-Biserial Correlation value of $r = 0.667$ indicates that differentiated learning has a strong influence on improving students' math skills.

In addition, the Mann-Whitney test on the posttest scores of arithmetic skills between the experimental and control groups showed a significant difference with a Z value of -2.470 and $p = 0.014 < 0.05$. The experimental group had a mean rank of 17.06, higher than the control group, which was only 9.55, which confirms that differentiated learning provides better results than conventional learning in students' arithmetic skills.

Theoretically, this relationship is in line with the view of NCTM and Hiebert which emphasizes that conceptual and procedural knowledge are two inseparable aspects of mathematics learning. Conceptual understanding provides a logical basis for applying procedures, while procedural skills strengthen and deepen conceptual understanding through repeated and meaningful practice. This relationship emphasizes that both abilities are interrelated and develop simultaneously (Hussein, 2022).

Differentiated learning in this study has been shown to develop both aspects simultaneously. Process differentiation provides students with opportunities to construct concepts through various representations and discussions, while simultaneously practicing numeracy skills through tiered exercises appropriate to their level of readiness. This allows students to learn within their zone of proximal development, allowing both conceptual understanding and procedural skills to develop optimally.

This study also shows that differentiated learning has a significant effect on improving conceptual understanding and mathematical calculation skills of fifth-grade students. The increase in conceptual understanding that is in the very large effect category shows that differentiated learning is able to accommodate students' abilities and learning needs optimally.

The finding that students with low to moderate initial abilities achieved greater improvement than students with high abilities demonstrates the effectiveness of differentiated learning in accommodating diversity. Theoretically, this can be explained through the concept of scaffolding. Vygotsky and principles *adaptive instruction*, where targeted learning support helps students at an early developmental level achieve higher competencies. Thus, differentiation not only improves average learning outcomes but also contributes to reducing the ability gap between students (Wibowo et al, 2025).

Differentiated learning provides students with opportunities to explore mathematical concepts through strategies, activities, and difficulty levels tailored to each student's individual characteristics. This allows students to develop a deeper and more meaningful understanding of concepts.

In terms of numeracy skills, differentiated learning has also been shown to have a significant, strong impact. This indicates that differentiated learning not only improves conceptual aspects but also positively impacts students' procedural abilities in solving mathematical problems.

Furthermore, the correlation analysis revealed a strong relationship between conceptual understanding and students' mathematical arithmetic skills. This finding confirms that conceptual understanding is a crucial foundation for developing arithmetic skills. The negative relationship between students' initial abilities and improved learning outcomes indicates that differentiated learning is highly effective for students with low to moderate abilities, as they receive learning support tailored to their needs.

Overall, the results of this study confirm that differentiated learning significantly improves students' conceptual understanding and mathematical arithmetic skills simultaneously. The strong relationship between these two variables indicates that strengthening concepts through differentiation strategies will directly impact the improvement of arithmetic skills, and vice versa. These findings strengthen the theoretical basis that effective mathematics learning must integrate the development of conceptual understanding and procedural skills in a balanced manner through an approach that is responsive to the differences in student characteristics.

The findings of this study strengthen the results of previous research, which found that differentiated learning in the Independent Curriculum significantly impacted elementary school students' mathematical problem-solving abilities (Diokta Ardani et al., 2024). These results align with this study, which showed significant improvements in conceptual understanding, a key prerequisite for problem-solving.

The implementation of differentiated learning based on learning styles can improve conceptual understanding and student engagement in mathematics learning (Irnelia et al., 2025). These similar findings confirm that adapting the learning process to student characteristics is a key factor in building deeper conceptual understanding. Furthermore, differentiated learning strategies have a positive impact on elementary school students' literacy and numeracy, which includes aspects of conceptual understanding and numeracy skills (Fitriyana & Dewi Nirmala, 2024).

Differentiated learning can improve students' understanding through a variety of strategies and media tailored to their needs (Purnasari & Alfiandra, 2024). Furthermore, differentiated learning significantly improves students' mathematics learning outcomes and numeracy skills. These findings are consistent with the results of this study, which showed that differentiated learning is effective in improving both

conceptual and procedural aspects of mathematics (Sabarikun & Heru Purnomo, 2023).

Novelty (*novelty*) This research is based on the study of the influence of differentiated learning processes simultaneously on two main indicators of numeracy, namely conceptual understanding and numeracy skills, accompanied by an analysis of the effect size and correlational relationship between the two. Thus, this research not only confirms the results of previous research but also provides more comprehensive empirical evidence regarding the strength of the influence of differentiated learning processes in the context of fifth-grade elementary school students.

However, this study still has several limitations. First, the sample size was relatively limited, involving only two classes in one school cluster. Therefore, generalizing the results to a wider population requires caution. Second, the implementation of differentiated learning in this study focused more on aspects of process differentiation, thus not fully describing the influence of content differentiation and product differentiation on student numeracy improvement. Third, the quasi-experimental research design was influenced by external factors that could not be fully controlled, such as differences in students' initial characteristics or learning conditions in each class. Fourth, the relatively limited duration of the research treatment did not fully describe the long-term impact of the implementation of differentiated learning on the development of students' mathematical abilities.

4. CONCLUSION AND SUGGESTIONS

Based on the research results and discussion, it can be concluded that differentiated learning has a significant effect on the conceptual understanding and mathematical calculation skills of fifth-grade students. The higher average increase in posttest scores in the experimental class indicates that process differentiation based on learning readiness is able to strengthen students' conceptual structure while increasing the accuracy and fluency of calculation. The finding of a positive and significant correlation between conceptual understanding and calculation skills confirms that both aspects support each other in building complete numeracy skills. Adaptive and responsive learning to student diversity has been proven to create more meaningful learning experiences. Therefore, teachers are advised to consistently conduct initial diagnostic assessments and apply process differentiation strategies in mathematics learning. Schools also need to support the development of teacher competencies so that differentiated learning practices can be implemented sustainably and effectively.

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