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Optimizing Mathematics Learning in Elementary Schools: A Differentiated Approach to Improving Students' Cognitive Abilities

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Abstract. This study aims to test the effectiveness of the application of differentiation approaches in mathematics learning in elementary school and its impact on students' cognitive abilities. This study used a quantitative experimental design with two groups, namely the experimental group that was treated with a differentiated approach and the control group that followed conventional learning. The sample consisted of two classes, namely the experimental class with 24 students and the control class with 25 students. Data was collected through math ability tests and motivation questionnaires, which were analyzed using a t-test to see significant differences between groups. The results showed that the experimental group that used the differentiation approach experienced significant improvements in concept comprehension, problem-solving skills, and learning motivation, compared to the control group. These findings imply that a differentiated approach can improve the quality of mathematics learning in primary schools, by tailoring teaching to the individual needs of students. Therefore, the application of a differentiation approach is recommended to improve student learning outcomes.

Keywords: Cognitive Ability; Differentiation Learning; Elementary School; Learning Motivation; Mathematics

1. INTRODUCTION

Mathematics is one of the most important subjects in the basic education curriculum, as it provides the basics of logical and analytical thinking that are essential for students' intellectual development (Muhtadi et al., 2022). Effective math learning can facilitate students in solving problems, developing critical thinking skills, as well as preparing them for the challenges of daily life (Amalia et al., 2017). However, despite its importance, math is often considered a difficult and challenging subject, especially for students at the elementary school level. This is largely due to differences in students' ability to understand abstract and complex mathematical concepts.

Based on the results of preliminary studies conducted in several elementary schools, it was found that the majority of students had difficulty understanding mathematics material (Susanti et al., 2020). This problem is often caused by a uniform teaching approach, which does not take into account individual student differences in terms of learning abilities and styles (Grecu, 2023). Students with higher abilities tend to feel bored with material that is considered too easy, while

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students with lower abilities find it difficult to keep up with the lessons. This has an impact on the uneven learning outcomes of mathematics in the classroom.

The differentiated approach in learning is one of the alternative solutions to overcome this problem. This approach emphasizes the importance of adjusting learning according to students' needs, interests, and abilities (Suprayogi et al., 2017). In the context of mathematics, the differentiation approach can be carried out in various ways, such as modifying materials, teaching methods, and assigning assignments that are in accordance with the student's ability level and learning style. Previous research has shown that differentiation approaches can improve student learning outcomes in a variety of subjects, including mathematics, by providing a wider opportunity for students to understand the material in a way that is most appropriate for them (Deunk et al., 2018; Smale-Jacobse et al., 2019).

Although the differentiation approach has been extensively discussed in various studies, most of those studies have focused more on secondary and college education levels (Lindner & Schwab, 2020; Yadav, 2020). The implementation of this approach at the elementary school level, especially in the context of mathematics learning, is still limited. In addition, although there has been research linking the differentiation approach to improving mathematics learning outcomes, there is still little research exploring its impact on improving students' cognitive abilities, particularly in terms of concept understanding and problem-solving skills.

This study aims to investigate how the application of differentiated learning approaches can affect students' cognitive abilities in mathematics learning in elementary school. In particular, this study will examine the influence of differentiation approaches on students' understanding of mathematical concepts and problem-solving skills. It is hoped that with a differentiated approach, each student will have the opportunity to learn according to their abilities and needs, so as to improve mathematics learning outcomes more evenly. Therefore, this research will focus on the application of differentiation approaches in mathematics classrooms in elementary schools and its impact on students' cognitive abilities.

2. METHOD

Research Design

This study uses a quantitative experimental design with a pre-test post-test control group design approach. In this design, two groups of students will be given different treatments. The experimental group will follow mathematics learning with a differentiation approach, while the control group will follow mathematics learning with a conventional approach. The measurement of students' cognitive abilities is carried out by giving tests before (pre-test) and after (post-test) treatment to find out the extent of the differences in abilities that occur in each group.

Population and Sample

The population in this study is all students of grade V of State Elementary School 002 Rambah. The research sample consisted of two randomly selected classes, namely the experimental class and the control class. The experimental class consisted of 24 students, while the control class consisted of 25 students. Class selection is made based on the similarity of student characteristics, such as age and relatively similar background in mathematical ability. These two classes will be treated differently, but the material taught remains the same to ensure that the difference in learning outcomes is due to the approach applied, not to other factors.

Research Instruments

The main instrument used in this study is a mathematical ability test consisting of questions about basic calculation operations, geometry, and problem solving. This test is designed to measure students' understanding of mathematical concepts as well as their ability to solve math problems. The test is given twice, namely before treatment (pre-test) and after treatment (post-test). In addition to the math ability test, the motivation questionnaire was also used to measure the level of students' motivation towards learning mathematics in both groups. This questionnaire is compiled based on the Likert scale which covers various aspects of learning motivation, such as interest, effort, and perception of mathematics.

Research Procedure

Data Analysis Techniques

The data obtained from the results of the pre-test and post-test tests will be analyzed using the t-test to see significant differences between the experimental group and the control group. The t-test was used to compare the average pre-test and post-test scores in the two groups. In addition, descriptive analysis was also used to describe the overall research results, including the comparison of the average pre-test and post-test scores of each group. Data from the motivation questionnaire will be analyzed descriptively to see if there is a significant difference in learning motivation between the two groups after treatment.

3. RESULTS

1. Descriptive Analysis of Pre-test and Post-test Data

This study aims to test the effectiveness of the application of differentiation approaches in mathematics learning in elementary schools, as well as its impact on students' cognitive abilities. Data obtained from the pre-test and post-test tests showed significant differences between the two experimental groups using a differentiation approach and the control group that followed conventional learning.

Before treatment, both the experimental and control groups had similar mathematical abilities, with almost the same average pre-test scores. The experimental group obtained an average pre-test score of 65.3, while the control

group obtained an average pre-test score of 64.5. These values reflect a student's relatively equal initial understanding of the fundamentals of mathematics.

However, after treatment, significant results begin to be seen. The experimental group that used the differentiation approach showed a fairly high improvement in understanding of mathematical concepts and problem-solving skills. The average post-test score for the experimental group reached 85.7, a significant increase compared to their pre-test score. In contrast, the control group that used the conventional approach showed only a smaller improvement, with an average post-test score of 75.6.

Table 1: Average Results of Pre-test and Post-test Experimental and Control Groups

Groups	Average Pre-test Score	Average Post-test Score	P-Value
Experimental Group	65,3	85,7	0,03
Control Group	64,5	75,6	0,12

The results of the t-test showed that the experimental group experienced significant changes, with a value of p = 0.03, which suggests that the application of the differentiation approach had a major effect on improving students' mathematical skills. On the other hand, the control group showed no significant change (p = 0.12), suggesting that conventional approaches did not have a significant impact on improving mathematics learning outcomes.

2. Learning Motivation Analysis

In addition to measuring mathematical ability, this study also measures students' motivation in learning mathematics. Learning motivation was measured using a questionnaire consisting of various indicators such as interest in mathematics, effort in learning, and perception of difficulties in mathematics subjects. Motivation scores before and after treatment showed a significant improvement in the experimental group, but not in the control group.

In the experimental group, the average motivation score of students before treatment (pre-test) was 3.2 (scale 1-5), while after being given a differentiated approach, their motivation score increased to 4.1. This shows that students in the experimental group feel more motivated to learn mathematics after applying learning that is tailored to their needs and abilities. A differentiated approach that accommodates students' different learning styles and speeds makes them feel more valued and better able to overcome learning difficulties.

In contrast, the control group experienced only a smaller increase in motivation. The control group's average motivation pre-test score was 3.1, and after treatment, their average post-test score only increased to 3.6. Although there was an improvement, this difference was not as large as seen in the experimental group. This suggests that although conventional learning increases student

motivation in some aspects, the impact is not as great as a differentiated approach that prioritizes active involvement and individual student needs.

Table 2: Average Results of Learning Motivation Score

Groups	Average Motivation Pre-test Score	Average Motivation Post-test Score
Experimental Group	3,2	4,1
Control Group	3,1	3,6

3. Analysis of Changes in Students' Cognitive Abilities

In addition to math ability tests and motivation questionnaires, this study also analyzed changes in students' cognitive abilities in solving math problems. The problem-solving test used to measure students' ability to identify and solve math problems shows similar results to other pre-test and post-test tests.

In the experimental group, students' problem-solving skills showed a significant improvement. The average problem-solving score before treatment was 67.4, while after treatment, the average score increased to 88.1. This shows that the differentiation approach not only improves the understanding of mathematical concepts, but also improves students' ability to solve more complex mathematical problems.

The control group, although improved, did not show a significant change in their problem-solving abilities. The average pre-test problem-solving score of the control group was 66.8, while after treatment, the average score increased to 77.3. This increase was smaller than in the experimental group, which indicates that conventional learning is less effective in improving students' problem-solving skills.

Table 3: Average Results of Problem-Solving Ability Score

Groups	Average Problem-solving Pre-test Score	Average Post-test Problem-solving Score
Experimental Group	67,4	88,1
Control Group	66,8	77,3

4. The Relationship Between Differentiated Learning and Learning Outcomes

Based on the results of this study, it can be concluded that learning with a differentiated approach has a significant influence on students' mathematics learning outcomes in elementary school. Students who learn with a differentiated approach show greater improvements in terms of their concept understanding, problem-solving abilities, and learning motivation compared to students who learn with a conventional approach. A differentiation approach that is more flexible and accommodates the individual needs of students can help increase student engagement in the learning process, which in turn improves overall math learning outcomes.

Thus, the application of a differentiated approach in mathematics learning

in primary school can be an effective alternative to improve student learning outcomes, especially in terms of understanding basic mathematical concepts and developing critical thinking and problem-solving skills.

4. DISCUSSION

This study revealed significant results in the application of differentiation approaches in mathematics learning in elementary schools. These findings are in line with educational theory that emphasizes the importance of approaches that tailor learning to the individual needs of students. In mathematics learning, where many students have varying levels of understanding, differentiation approaches have proven to be more effective compared to conventional learning (Deunk et al., 2018). The results showed that the experimental group that followed the differentiation approach experienced a significant improvement in understanding of mathematical concepts and problem-solving skills, while the control group that used the conventional approach showed only a relatively small improvement. This shows that an approach that accommodates students' differences in abilities and learning styles can improve their learning outcomes more evenly (Sak & Ayas, 2020).

One of the reasons why experimental groups show greater improvement is because the differentiation approach provides opportunities for students to learn according to the pace and manner that best suits their abilities (Thongkoo et al., 2023). In a differentiated approach, students are given different types of assignments and materials tailored to their needs, allowing them to understand mathematical concepts in a more effective way. For example, students with higher abilities may be given more complex challenges, while students with greater difficulties may be given simpler material and more detailed explanations. This approach not only improves conceptual comprehension, but also allows students to experience success in learning, which in turn increases motivation (Suprayogi et al., 2017).

Learning motivation is a key factor that plays a role in improving student learning outcomes (Ginja & Chen, 2020). In this study, students who participated in differentiated learning showed a more significant increase in motivation compared to the control group. This shows that when students feel that the material being taught is in accordance with their abilities and interests, they will be more motivated to learn. The differentiation approach gives students the freedom to choose the way of learning that suits them best, either through group discussions, projects, or the use of more visual and interactive learning media. These results are in line with the findings of previous research that showed that students' motivation increases when they feel valued and engaged in the learning process (In'am & Sutrisno, 2020).

The improvement of problem-solving skills in the experimental group also gives an idea that the differentiation approach not only improves understanding

of mathematical concepts, but also strengthens students' ability to solve more complex mathematical problems (Ramadhani, 2018). This suggests that the differentiation approach focuses on developing students' critical thinking and analytical skills, which are crucial in mathematics learning (Musna et al., 2021). On the other hand, the control group that accepted the conventional approach showed only a limited improvement in problem-solving skills. This smaller increase may be related to the lack of variety in assignments and approaches given to students in conventional math learning.

These findings confirm that mathematics learning with a differentiated approach has a greater impact on student learning outcomes, especially in terms of concept comprehension, problem-solving skills, and learning motivation. The differentiated approach allows for more inclusive learning and is responsive to the individual needs of students, thereby improving the quality of learning in primary schools. Therefore, it is recommended that the differentiation approach be applied more widely in primary schools to improve mathematics learning outcomes, as well as to create a more engaging and challenging learning atmosphere for students.

5. CONCLUSION

The importance of applying a differentiated approach in mathematics learning in elementary school, especially to improve concept understanding, problem-solving skills, and student learning motivation. This approach can provide a more inclusive and responsive learning experience to individual student differences, thereby improving the quality of learning outcomes. Therefore, schools and teachers need to consider adapting a differentiated approach in their curriculum and teaching methods, so that each student can learn in a way that best suits their needs and abilities.

The suggestion that can be given based on the results of this study is for educators at the elementary school level to be more active in developing and implementing learning strategies that are flexible and can be adjusted to the needs of students. In addition, it is important for teachers to continuously improve their skills in designing different materials and assignments, as well as using a variety of teaching methods that can accommodate students' diverse learning styles. Further research is also needed to identify the challenges that may be faced in the application of differentiation approaches in mathematics classrooms and how to address those challenges so that they can be applied effectively in various educational contexts.

6. REFERENCES

Amalia, E., Surya, E., & Syahputra, E. (2017). The effectiveness of using problem based learning (PBL) in mathematics problem solving ability for junior high school students. *International Journal of Advance Research and Innovative*

Ideas in Education, *3*(2), 3402–3406.

Deunk, M. I., Smale-Jacobse, A. E., de Boer, H., Doolaard, S., & Bosker, R. J. (2018). Effective differentiation practices: A systematic review and meta-analysis of studies on the cognitive effects of differentiation practices in primary education. *Educational Research Review*, *24*, 31–54.

Ginja, T. G., & Chen, X. (2020). Teacher educators' perspectives and experiences towards differentiated instruction. *International Journal of Instruction*, *13*(4), 781–798. https://doi.org/10.29333/iji.2020.13448a

Grecu, Y. V. (2023). Differentiated instruction: Curriculum and resources provide a roadmap to help English teachers meet students' needs. *Teaching and Teacher Education*, *125*, 104064. https://doi.org/10.1016/j.tate.2023.104064

In'am, A., & Sutrisno, E. S. (2020). Strengthening students' self-efficacy and motivation in learning mathematics through the cooperative learning model. *International Journal of Instruction*, *14*(1), 395–410. https://doi.org/10.29333/IJI.2021.14123A

Lindner, K.-T., & Schwab, S. (2020). Differentiation and individualisation in inclusive education: a systematic review and narrative synthesis. *International Journal of Inclusive Education*, 1–21. https://doi.org/10.1080/13603116.2020.1813450

Muhtadi, A., Assagaf, G., & Hukom, J. (2022). Self-efficacy and students' mathematics learning ability in Indonesia: A meta analysis study. *International Journal of Instruction*, *15*(3), 1131–1146. https://doi.org/10.29333/iji.2022.15360a

Musna, R. R., Juandi, D., & Jupri, A. (2021). A meta-analysis study of the effect of Problem-Based Learning model on students' mathematical problem solving skills. *Journal of Physics: Conference Series*, *1882*(1), 12090.

Ramadhani, R. (2018). The enhancement of mathematical problem solving ability and self-confidence of students through problem based learning. *Jurnal Riset Pendidikan Matematika*, *5*(1), 127–134. https://doi.org/10.21831/jrpm.v5i1.13269

Sak, U., & Ayas, B. (2020). EPTS Curriculum Model: Optimum curriculum differentiator for the education of gifted students. *Gifted Education International*, *36*(2), 154–169. https://doi.org/10.1177/0261429420917879

Smale-Jacobse, A. E., Meijer, A., Helms-Lorenz, M., & Maulana, R. (2019). Differentiated Instruction in Secondary Education: A Systematic Review of Research Evidence. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.02366

Suprayogi, M. N., Valcke, M., & Godwin, R. (2017). Teachers and their implementation of differentiated instruction in the classroom. *Teaching and Teacher Education*, *67*, 291–301. https://doi.org/10.1016/j.tate.2017.06.020

Susanti, N., Juandi, D., & Tamur, M. (2020). The effect of problem-based learning (PBL) model on mathematical communication skills of Junior High School students – A meta-analysis study. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *4*(2), 145. https://doi.org/10.31764/jtam.v4i2.2481

Thongkoo, K., Daungcharone, K., & Thanyaphongphat, J. (2023). Blended learning-driven interdisciplinary project-based approach: Gender differences in learning achievement and perceptions of university students. *2023 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and*

Telecommunications Engineering (ECTI DAMT & NCON), 143–147. https://doi.org/10.1109/ECTIDAMTNCON57770.2023.10139599

Yadav, A. B. (2020). Differentiating Instruction 21st Century Classrooms. *SSRN Electronic Journal*, *1*(1), 53–59. https://doi.org/10.2139/ssrn.3512793