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# Enhancing Mathematical Problem-Solving Skills Through Flipped Classrooms and Discovery Learning: A Resilience-Based Approach for Elementary Students

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**ABSTRACT**

Mathematical problem-solving skills are essential for elementary students and can be enhanced through innovative teaching approaches. This study investigates the effectiveness of Discovery Learning and Flipped Classroom models in improving problem-solving abilities among fifth-grade students. A quasi-experimental design was employed with two experimental groups: one taught using Discovery Learning and the other using the Flipped Classroom model. The study involved 60 randomly selected fifth-grade students. Data collection was conducted using pretest and posttest assessments to evaluate mathematical problem-solving skills. The results indicate that students in the Discovery Learning group demonstrated a significantly greater improvement in their problem-solving scores compared to those in the Flipped Classroom group. The findings suggest that the interactive and exploratory nature of Discovery Learning contributes more effectively to the development of critical thinking and collaborative problem-solving skills. The study highlights the potential of Discovery Learning in fostering deeper understanding and engagement in mathematical problem-solving. While the Flipped Classroom also showed positive effects, Discovery Learning proved to have a stronger impact, suggesting its suitability for enhancing problem-solving capabilities in elementary education. Discovery Learning is more effective than the Flipped Classroom in improving mathematical problem-solving skills among fifth-grade students. These findings underscore the importance of adopting active learning approaches to strengthen critical and collaborative skills in mathematics education.



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## 1. INTRODUCTION

Problem-solving ability is a crucial skill in the 21st century, given the increasing complexity of challenges faced by modern society. In education, particularly in mathematics, mastering this skill is essential as it forms the foundation for logical and analytical thinking. Despite its importance, many students struggle to deeply understand mathematical concepts and apply them to solve real-world problems. This issue highlights the need for effective educational approaches that enhance problem-solving skills.

The conceptualization of thinking processes is guided by the revised Bloom's Taxonomy, which comprises two dimensions: the knowledge dimension and the cognitive process dimension. The cognitive process dimension includes six hierarchical categories: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. These categories represent a progressive framework for fostering critical and analytical thinking. Additionally, Rahman (2019) identifies ten key 21st-century skills organized into four groupings: Ways of Thinking (creativity, innovation, critical thinking, problem-solving, decision-making, learning to learn, and metacognition), Ways of Working (communication and collaboration), Tools for Working (information literacy and ICT literacy), and Living in the World (citizenship, life and career skills, and cultural awareness and competency).

These frameworks emphasize the necessity of integrating problem-solving into education to equip students with the skills required to navigate and excel in a rapidly evolving world.

Some of the abilities above must be fulfilled in learning Mathematics in the 21st century, because life in the 21st Century requires quality human resources to survive in the world of global competition. Quality humans come from a quality education process, where everything cannot be separated from the thinking process. The ability to solve problems is very important for humans to compete in the global world (Durrotunnisa & Nur, 2020). The 21st century is focused on developments with the era of industrial revolution 4.0 which places information as the main spearhead, one of which is the development of problem-solving skills so that they become the basic capital for meaningful learning today (Limbong, Munawar, & Kusumaningtyas, 2019)(Sari & Atmojo, 2021).

The ability to think critically and solve problems is a prerequisite in the 21st-century global landscape, characterized by complexity and rapid change (Zakiyah et al., 2022). Problem-solving is one of the core strategies emphasized in 21st-century skills and serves as a fundamental aspect of the mathematics curriculum. Through problem-solving, students gain valuable experience applying their existing knowledge and skills to tackle non-routine problems, fostering deeper learning and adaptability (Prismana, Kusmayadi, & Pramudya, 2018).

Research (Garofalo & Lester, 2020; Harskamp, Suhre, & Van Streun, 2000; Schoenfeld, 1987) indicates that students' struggles with problem-solving often stem not from a lack of mathematical knowledge but from the inability to utilize it effectively (Harskamp & Suhre, 2007; Suhre, Jansen, & Harskamp, 2007). Schoenfeld (1987) argues that students must learn to set goals and regulate their problem-solving behavior to successfully address non-standard mathematical problems. According to Polya and Conway (2014), problems can be categorized as routine—those easily solved using familiar methods—and non-routine, which require creativity and novel strategies.

Further studies (Goos, 2002; Teong, 2003) validate Schoenfeld's findings, highlighting that effective problem solvers can represent problem situations in multiple ways, such as sketches, graphs, tables, or numerical examples. These skills are crucial for navigating the challenges of the modern world (Purnama, 2020). The essence of problem-solving lies in thinking critically, analyzing situations, and understanding them to make informed decisions and solve problems effectively (Kurino, 2018).

Polya's ideas about problem-solving influenced the field of educational mathematics for decades (Nisa & Wandani, 2023). NCTM's 1980s call for problem-solving to be "the focus of school mathematics" was widely echoed in mathematics education (NCTM, 2000). This is one reason why emphasizing problem solving in reports needs to be addressed. Teaching problem solving skills is a teacher's obligation, because it can motivate students to solve the problems they face. Learning emphasizes the importance of multidisciplinary collaboration in solving problems and analyzing students' problems.

The 2018 PISA study revealed that the average mathematics score of Indonesian students was 379, significantly below the OECD average of 487 (OECD, 2019). This highlights a critical gap in the mathematical proficiency of students, particularly in problem-solving—a fundamental skill emphasized by the National Council of Supervisors of Mathematics (NCSM) as the primary reason for learning mathematics. Resilience, a crucial psychological factor, plays a significant role in overcoming challenges during the problem-solving process. However, many students lack this resilience and often struggle when first encountering complex mathematical problems (Kleden, 2015).

While Discovery Learning and Flipped Classroom models have shown potential in fostering critical thinking and problem-solving abilities, research comparing their relative effectiveness in enhancing these skills, especially among elementary school students, remains limited. Preliminary data from 28 elementary students revealed that only 32% achieved scores above the KKM benchmark (70), while 68% scored below it. Interviews with teachers and students further indicated challenges in integrating effective problem-solving strategies into daily mathematics lessons.

This study addresses this gap by comparing the impact of Discovery Learning and Flipped Classroom models on students' problem-solving abilities and resilience in mathematics learning. The novelty lies in examining these models side-by-side to determine their effectiveness in developing critical skills. The findings are expected to contribute significantly to mathematics education, providing educators with evidence-based strategies to improve problem-solving outcomes and foster resilience, ultimately preparing students to face academic and real-world challenges more effectively.

## 2. METHODS

This study employs a quantitative research method to address the research problem. Quantitative methods are effective in systematically collecting, analyzing, and interpreting numerical data to draw meaningful conclusions. Data collection and analysis were conducted simultaneously or within a short time interval, ensuring efficiency and consistency in the research process.

Due to the pre-existing class structures, randomization of research subjects was not feasible. Therefore, a quasi-experimental design was adopted, which is suitable for comparing the effects of different interventions in natural classroom settings. This design aims to identify differences in the improvement of problem-solving abilities between two groups subjected to different treatments.

The study involved two classes: an experimental group employing the Discovery Learning model and the Flipped Classroom model, and a control group following a traditional instructional approach. The independent variables are the Discovery Learning and Flipped Classroom models, while the dependent variable is students' problem-solving abilities, with resilience serving as a moderating variable.

The research was conducted with fifth-grade students (classes V-A and V-B) at an elementary school in Majalengka. Instruments used for data collection included a problem-solving ability test to measure mathematical proficiency and a resilience questionnaire to evaluate students' psychological adaptability. To analyze the data, an ANOVA test was employed, allowing for a robust comparison of the improvements in problem-solving abilities between the two groups. This method provides insights into the effectiveness of the learning models and their potential to enhance both cognitive and psychological skills in elementary education.

## 3. FINDINGS AND DISCUSSION

The findings obtained in this research in the form of pretest and poster data (achievement scores) and the increase in mathematical problem solving abilities are summarized in table 1 and table 2 as follows.

**Table 1.** Pretest and Posttest Scores on Students' Mathematical Problem Solving Ability Using Discovery Learning

| | Pretest | Postest | N-Gain |
|---|---|---|---|
| Average | 61.66667 | 81 | 19.33333 |
| Maximum | 75 | 100 | 35 |
| Minimum | 45 | 70 | 0 |
| Standard Deviation | 7.58098 | 7.474093 | 8.68345 |

The results of the data analysis showed an increase in students' problem-solving abilities after being given the discovery learning model. This can be seen from the average posttest score which reached 81, higher than the average pretest score of 61.67, with an average increase (N-Gain) of 19.33. The maximum score also increased from 75 in the pretest to 100 in the posttest, while the minimum score increased from 45 to 70. The pretest standard deviation of 7.58 decreased slightly to 7.47 in the posttest, indicating a more even distribution of student scores after learning. The maximum N-Gain score reached 35, while the minimum score was at 0, indicating variations in the level of improvement in students' abilities after following this learning model. Overall, these data indicate that the use of the discovery learning model is effective in improving students' problem-solving abilities.

The table above explains the results of the pretest and posttest of mathematical problem solving abilities in grade V elementary schools. Of the 30 students who carried out the pretest, there were eight students who got scores above 70. This requires improvement in the learning process related to the volume material. cube and block space. So that after the treatment was carried out, overall students carried out the posttest with the average student score increasing from the pretest before treatment with Discovery learning.

Based on the data above, there are also students who used the flipped classroom learning model who obtained pretest and posttest scores as follows.

**Table 2.** Pretest and Posttest Scores for the Mathematical Problem Solving Ability of Students Studying in a Flipped Classroom

| | Pretest | Postest | N-Gain |
|---|---|---|---|
| Average | 61.78 | 79.1 | 17.34 |
| Maximum | 75 | 95 | 35 |
| Minimum | 50 | 70 | 0 |
| Standard Deviation | 5.96 | 6.62 | 7.81 |

The results of the analysis showed an increase in students' problem-solving abilities after being given learning using the flipped classroom model. The average posttest score increased to 79.13 compared to the average pretest score of 61.78, with an average increase value (N-Gain) of 17.34. The maximum score increased from 75 in the pretest to 95 in the posttest, while the minimum score also increased from 50 to 70. The standard deviation of the pretest score was 5.97, slightly increasing to 6.62 in the posttest, indicating a slightly larger variation in student scores after learning. The highest N-Gain score was recorded at 35, while the lowest score was 0. These data indicate that the flipped classroom model contributes positively to improving students' problem-solving abilities, although there is variation in the level of success between students. For the purposes of data analysis related to the answers to this research question, table 3 is displayed which concerns the scores for obtaining mathematical problem solving abilities for those studying with Discovery Learning and Flipped Classroom, taking into account the level of resilience.

**Table 3.** Achievement scores for problem solving abilities of students who received Discovery Learning and Flipped Classroom taking into account the level of resilience

| | **Discovery Learning** | | | **Flipped Classroom** | | |
|---|---|---|---|---|---|---|
| | **High Resilience** | **Medium Resilience** | **Low Resilience** | **High Resilience** | **Medium Resilience** | **Low Resilience** |
| Rate-rate | 73.18 | 64.10 | 57.75 | 73.91 | 65.70 | 66.43 |
| Maximum Value | 80 | 67 | 60 | 80 | 70 | 70 |
| Minimum Value | 69 | 60 | 54 | 70 | 64 | 65 |
| Standard Deviation | 3.22 | 2.23 | 2.66 | 2.88 | 1.89 | 1.81 |

The results of the analysis show that the Discovery Learning and Flipped Classroom learning models have different effectiveness based on the level of student resilience. For students with high resilience, both models provide good results, although Flipped Classroom shows a slight advantage in the average score. Meanwhile, students with medium and low resilience tend to benefit more from the Flipped Classroom approach, which provides a more even and consistent increase in learning outcomes. This indicates that Flipped Classroom is more effective in supporting students with lower levels of resilience, while Discovery Learning still provides optimal results for students with high resilience. Overall, Flipped Classroom appears to be more flexible for various levels of resilience, making it a more inclusive option in improving students' problem-solving abilities. Based on the table above, we will analyze: 1) The difference in the influence of Discovery Learning and Flipped Classroom on improving mathematical problem solving abilities. 2) Differences in the influence of students' levels of mathematical resilience on increasing students' mathematical problem solving abilities. 3) The influence (effect) of the interaction between learning (*Discovery Learning dan Flipped Clasroom*) and the level of students' mathematical resilience towards increasing students' mathematical problem solving abilities.

Based on the findings above, it can be seen from the data on elementary school students' mathematics problem solving ability scores in the pretest and posttest using discovery learning and flipped classroom learning. That the results of the analysis using SPSS, namely the answer to the research question above, depends on whether each of the following three hypotheses is rejected and accepted: 1) Hypothesis 1: There is a difference in the influence of Discovery Learning and Flipped Classroom on increasing students' mathematical problem solving abilities. 2) Hypothesis 2: There is a difference in the influence of students' level of mathematical resilience on increasing students' problem solving abilities. 3) Hypothesis 3: There is an interaction influence (effect) between learning (*Discovery Learning* And *Flipped Clasroom*) and the level of students' mathematical resilience (high, medium and low) towards increasing students' mathematical problem solving abilities. Formally, a statistical hypothesis ($H_0$) and the research hypothesis ($H_1$), from Hypothesis 1, Hypothesis 2 and Hypothesis 3, respectively, are as follows:

1. $H_0$ : $\alpha_1 = \alpha_2$
   $H_1$: $\alpha_1 \neq \alpha_2$

notes

$\alpha_i$ is the influence of learning

2. $H_0$ : ß$_1$ = ß$_2$= ß$_3$
   $H_1$ : not $H_0$

note: ß$_i$ is the level of resilience student.

3. $H_0$ : $\alpha_1$ ß$_1$= $\alpha_1$ ß$_2$ =$\alpha_1$ ß$_3$ = $\alpha_2$ ß$_1$ =$\alpha_2$ ß$_2$ =$\alpha_2$ ß$_3$
   $H_1$ : $\alpha_i$ ß$_j$ ¯0

Notes : $\alpha_i$ ß$_j$ is the interaction effect between learning and the level of resilience

The three hypotheses were tested using SPSS software, employing a two-way ANOVA test to analyze the data on the improvement of students' problem-solving abilities. This analysis considered the effects of both the Discovery Learning and Flipped Classroom models, along with the moderating influence of students' resilience levels. The results, based on the score data, are summarized in the table above, and the corresponding output is presented as follows:

**Table 4.** Hypothesis Testing

| Tests of Between-Subjects Effects | | | | | |
|---|---|---|---|---|---|
| **Dependent Variable: KPM_improvement_score** | | | | | |
| **Source** | **Type III Sum of Squares** | **df** | **Mean Square** | **F** | **Say.** |
| Corrected Model | 199.533[a] | 5 | 39.907 | 33.052 | <.001 |
| Intercept | 1363.267 | 1 | 1363.267 | 1129.086 | <.001 |
| Learning | 4.267 | 1 | 4.267 | 3.534 | .066 |
| Resilience_level | 193.633 | 2 | 96.817 | 80.186 | <.001 |
| Learning * Resilience_level | 1.633 | 2 | .817 | .676 | .513 |
| Error | 65.200 | 54 | 1.207 | | |
| Total | 1628.000 | 60 | | | |
| Corrected Total | 264.733 | 59 | | | |

From the output above, several important notes were obtained from the test of between subject effects:

1. Significant value on *corected* model is <0.001 and this value is smaller than 0.05 ($\alpha$) which means that the two way anova analysis model used in this research is valid.
2. The sig value of the intercept is <.001 and this value is smaller than 0.05 ($\alpha$)which means that changes in the constant are not influenced by changes in the independent variable.
3. The sig value for learning is <.066 and this value is smaller than 0.07 ($\alpha$)which means that $H_0$ Hypothesis 1 is rejected and $H_1$ accepted, which means that the hypothesis which states that: "There is a difference in the influence of Discovery Learning and Flipped Classroom on increasing students' mathematical problem solving abilities", is accepted. Based on the average, it turns out that Discovery Learning has a higher impact than Flipped Classroom learning on improving mathematical problem solving abilities. This is in line with Kusumaningrum & Indarini, (2020), that Model *Discovery Learning* is a model where students search for, investigate for themselves the problems they encounter, so that students actively solve the problems they face themselves with various new ideas and concepts.
4. The sig value for resilience is <.001 and this value is smaller than 0.05 ($\alpha$) which means that H0 in hypothesis 2 is rejected and H1 is accepted, which means that there is a difference in the influence of students' levels of mathematical resilience on the achievement of students' mathematical problem solving abilities. Based on the post hoc test (LSD) on the output of multiple comparisons, it turns out that students who have high resilience have a higher influence than students who have medium resilience and students who have low resilience on improving mathematical problem solving abilities and, students who have moderate resilience have a greater influence. higher than students with low resilience. In line with this, there are two ways to use discovery learning, namely

pure discovery, where learning is carried out without instructions or direction, and guided discovery where the teacher is the facilitator of the learning process.

5. From the output of Learning * resilience (interaction effect) the sig value is 0.513 and this value is greater than 0.05 (α) which means that $H_0$ is accepted, so it can be concluded that there is no influence (interaction effect) between learning and the level of resilience on increasing KPM.
6. From the output R Squared = .863 (Adjusted R Squared = .850) and this value is close to 1, which means that together (simultaneously) the learning model and students' mathematical resilience have a significant effect on the achievement of problem solving abilities.

In the mathematics learning process, appropriate learning models and students' resilience abilities play an important role in increasing their achievement, especially in the aspect of problem solving. Effective learning models, such as models that emphasize practical, collaborative, or problem-based learning approaches, can provide students with deeper and more relevant experiences in understanding mathematical concepts. When students are actively engaged and stimulated by a challenging yet supportive learning model, they are more likely to develop the critical and analytical thinking skills necessary for problem solving. When a supportive learning model is combined with a high level of mathematical resilience in students, both work simultaneously in supporting the achievement of better problem solving abilities (Fitri, Syahputra, & Syahputra, 2019; Hafiz, Darhim, & Dahlan, 2017; Lee & Johnston -Wilder, 2017). As a result, students not only understand mathematical material in depth but are also able to face and overcome challenges in solving complex mathematical problems.

Discovery Learning provides students with opportunities to actively explore mathematical concepts, either independently or with minimal guidance (Amir et al., 2024; Klahr & Nigam, 2004; Mabhoza & Olawale, 2024; Noverianto et al., 2024; Said et al., 2019). Its effectiveness in improving problem-solving skills is grounded in the constructivist approach and the principle of guided discovery. According to constructivist theory, meaningful learning occurs when students actively construct knowledge through exploration and interaction with their environment. Discovery Learning aligns with this principle by allowing students to engage directly in the process of discovering concepts, fostering deeper understanding and critical thinking.

The guided discovery aspect of Discovery Learning ensures that students receive appropriate support and direction from teachers when encountering challenges, reducing confusion and enhancing learning efficiency. Resilience is a key factor in mathematical problem-solving, as it enables students to cope positively with difficulties, stress, and setbacks. Students with high resilience are better equipped to navigate complex situations, maintain focus, and employ effective strategies to find solutions. They demonstrate emotional and mental fortitude, staying motivated despite obstacles such as errors or challenging problems. This resilience is also linked to greater self-confidence, encouraging students to experiment with various approaches until successful solutions are achieved.

Through self-exploration and guided discovery, students not only gain a deeper understanding of fundamental concepts but also enhance their critical and analytical thinking skills, essential for effective problem-solving. This model positions students as active learners, engaging them in trials and reflective processes that build robust problem-solving capabilities. However, a limitation of this study is its focus solely on elementary school students. Future research should explore the applicability of Discovery Learning across different educational levels to validate and expand its effectiveness.

## 4. CONCLUSION

The findings of this study reveal that Discovery Learning has a significantly greater impact than the Flipped Classroom model in enhancing students' mathematical problem-solving abilities, as indicated by a sig value of <.066, which is smaller than the 0.07 threshold ($\alpha$). This result supports the hypothesis that there is a difference in the effectiveness of these learning models, with Discovery

Learning demonstrating superior outcomes. The implications of this research suggest that school administrators and educators should prioritize the implementation of Discovery Learning in mathematics instruction. Steps such as teacher training, the provision of interactive teaching aids, and consistent monitoring can ensure its effective adoption and maximize its benefits in fostering problem-solving skills.

However, the study's scope was limited to elementary school students, which restricts the generalizability of its findings to other educational levels. Future research should address this limitation by extending the investigation to include junior high and high school students, exploring whether Discovery Learning yields similar advantages for older students with more advanced cognitive abilities and mathematical understanding. Additionally, future studies could examine the long-term effects of Discovery Learning on students' overall academic performance and resilience.

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