

Developing Differentiated Learning Model to Enhance Creative Mathematical Thinking

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Abstract: This study aims to develop a differentiated learning model based on open problem solving (DL-OPS) to enhance students' creative mathematical thinking skills. The research adopts the Plomp development model consisting of three phases: preliminary research, prototyping, and assessment. The subjects involved were mathematics teachers and 42 eighth-grade students at SMP Negeri 1 Jonggat. Data collection instruments included expert validation questionnaires, teacher and student response questionnaires, interviews, and creative thinking tests. The results showed that the developed model and its supporting materials (guidebook, textbook, and teaching module) were valid, practical, and effective. Validation scores from experts indicated a high level of validity. Teacher and student responses indicated that the model was practical in classroom implementation. Furthermore, students' creative thinking abilities significantly improved, with post-test average scores increasing from 8.21 (fairly creative) to 14.16 (creative), and the proportion of students in the creative and very creative categories rising from 37% to 87%. The model's core features—content, process, and product differentiation, integration of open-ended problems, and authentic assessments—create a learning environment that is flexible, reflective, and collaborative. This research contributes to innovative pedagogical practices aligned with 21st-century learning needs and supports individualized learning pathways to promote creativity in mathematics education.

Keywords: Differentiated Instruction, Open Ended Problem Solving, Mathematical Creative Thinking.

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A. INTRODUCTION

Mathematics education in Indonesia continues to face challenges in improving students' achievement and higher-order thinking skills. International assessments such as PISA (2018, 2022) reveal that Indonesian students still perform below the global average in mathematics, with difficulties in solving contextual and non-routine problems. This situation indicates the need for learning models that can accommodate diverse student characteristics while fostering creative thinking skills. Differentiated learning (Tomlinson, 2014; Kristiani et al., 2021; Demir, 2021) emphasizes adjustments in content, process, and product based on students' readiness, interests, and learning profiles. However, its application in classrooms often lacks integration with creative thinking development and open-ended exploration. On the other hand, open problem solving (Nohda, 2000; Sudiarta, 2019) allows students to explore multiple solution pathways and express original ideas, thereby supporting creativity in mathematics learning. Recent studies (Aguhayon et al., 2023; Rijal & Azimi, 2021) suggest that combining differentiated instruction with open-ended tasks can significantly improve students' problem-solving and creativity skills.

The importance of integrating differentiated learning with open-ended problem solving also relates to 21st-century education demands. Current curricula emphasize creativity, critical thinking, collaboration, and communication (4C skills), yet many classroom practices remain traditional and teacher-centered. As a result, students' opportunities to think divergently and generate innovative solutions are still limited (Nguyen & Le, 2023; Zhou & Kim, 2024). Developing a learning model that combines differentiation and open-ended tasks is therefore a strategic effort to address both individual learning needs and the cultivation of creative mathematical thinking.

Building on these perspectives, this study developed a Differentiated Learning Model based on Open Problem Solving (DL-OPS) to improve junior high school students' creative mathematical thinking. The novelty of this research lies in integrating differentiation principles with authentic open-ended problem contexts, which has been rarely implemented in Indonesian classrooms. This study also provides empirical evidence on the validity, practicality, and effectiveness of the DL-OPS model, making it relevant for mathematics educators, policymakers, and researchers who aim to strengthen innovative pedagogical practices.

B. METHOD

This study adopted a development research design using the Plomp model (2013), consisting of three phases:

1. Preliminary Research: Literature review, curriculum analysis, and classroom observations to identify problems.
2. Prototyping Phase: Developing the DL-OPS model, including guidebook, textbook, and teaching module, followed by expert validation and revisions.
3. Assessment Phase: Implementing the model in classroom settings, followed by evaluation of validity, practicality, and effectiveness.

Participants: Mathematics teachers and 42 eighth-grade students at SMP Negeri 1 Jonggat. Instruments: Expert validation questionnaires, teacher and student response questionnaires, interviews, creative thinking tests, and student appreciation surveys. Data Analysis: Descriptive statistics, Pearson correlation for validity, Cronbach's Alpha for reliability, paired-sample t-test for effectiveness, and normalized gain (N-Gain) analysis. Qualitative responses were analyzed thematically.

C. RESULTS AND DISCUSSION

RESULTS

1. Validity of the Model and Materials

Expert validation scores showed that the DL-OPS guidebook, textbook, and teaching module were valid. The textbook scored 59.33, and the teaching module scored 69.33. Test instruments demonstrated high validity (Pearson correlation > 0.369 ; $p < 0.05$) and reliability (Cronbach's Alpha = 0.737).

2. Practicality of the Model

Teacher responses averaged 56.5 (practical), and student responses averaged 8.97 (practical). Interviews confirmed that DL-OPS facilitated flexible grouping, differentiated tasks, and engaging classroom activities.

3. Effectiveness of the Model

Pre-test average score: 8.21 (fairly creative); Post-test average score: 14.16 (creative). The proportion of students categorized as creative or very creative increased from 37% (pre-test) to 87% (post-test). The N-Gain score was categorized as moderate to high. This indicates that the DL-OPS model was effective in improving students' creative mathematical thinking.

DISCUSSION

The findings of this study confirm that the Differentiated Learning Model based on Open Problem Solving (DL-OPS) is valid, practical, and effective in improving students' mathematical creative thinking. This aligns with the assertion of Tomlinson (2014, 2017) that differentiated instruction enables teachers to adapt learning content, process, and product to address diverse student needs. The validation scores obtained from experts demonstrate that the developed model was built on strong theoretical foundations and aligned with curriculum demands, ensuring that both the guidebook and teaching module could serve as reliable instructional tools.

In terms of practicality, the positive responses from both teachers and students indicate that DL-OPS can be realistically implemented in classroom contexts. Demir (2021) highlights that differentiated instruction fosters student engagement and accommodates multiple learning profiles, while Sudiarta (2019) emphasizes that open problem solving makes learning more interactive and meaningful. This combination allows students to take an active role in constructing mathematical understanding, thereby promoting student-centered learning environments. The interviews conducted further reinforced that teachers found DL-OPS flexible for grouping strategies and task variations, making classroom interactions more dynamic.

The effectiveness of DL-OPS is reflected in the significant improvement of students' mathematical creative thinking abilities from pre-test to post-test. The increase in students categorized as "creative" and "very creative" demonstrates the power of integrating open-ended problem solving with differentiated approaches. This is consistent with studies by Nohda (2000) and Nguyen and Le (2023), who argue that open-ended tasks enable students to explore multiple solution pathways and develop originality, fluency, flexibility, and elaboration. Furthermore, Zhou and Kim (2024) provide evidence that differentiated learning environments enhance creativity by supporting students' diverse cognitive and affective needs. The improvement in creative mathematical thinking also resonates with global educational demands for 21st-century skills, particularly critical thinking, problem solving, and creativity (Rijal & Azimi, 2021). By providing individualized pathways and authentic tasks, DL-OPS fosters a classroom culture where students are encouraged to take intellectual risks and collaborate to find innovative solutions. This model goes beyond traditional instruction by blending reflective learning practices with creativity-enhancing activities, creating a balance between academic rigor and student engagement.

Overall, DL-OPS represents an innovative contribution to mathematics pedagogy, particularly in the Indonesian context where differentiated instruction and open problem solving have been underutilized. The integration of these approaches not only addresses individual student differences but also cultivates creative skills essential for lifelong learning. These findings are consistent with Aguhayon et al. (2023), who found that differentiated instruction positively impacts mathematics performance, and further extend the literature by empirically showing that creativity can be significantly developed through a systematic model design. Thus, DL-OPS offers both theoretical and practical implications for enhancing mathematics education globally.

D. CONCLUSIONS AND SUGGESTIONS

This study concludes that the Differentiated Learning Model based on Open Problem Solving (DL-OPS) is valid, practical, and effective in enhancing students' mathematical creative thinking skills. The validity of the model was confirmed by expert evaluations, which indicated that the developed guidebook, textbook, and teaching module were aligned with theoretical foundations and curriculum requirements. In terms of practicality, teacher and student responses demonstrated that DL-OPS can be implemented in classroom settings with flexibility and positive engagement. The effectiveness of the model was evident in the significant improvement of students' creative thinking abilities, particularly in fluency, flexibility, originality, and elaboration indicators. Overall, DL-OPS provides an innovative pedagogical framework that integrates differentiation with open-ended problem solving, thereby fostering a reflective, collaborative, and creativity-oriented mathematics classroom.

1. Mathematics teachers are encouraged to adopt DL-OPS in classroom practice to accommodate diverse student needs while simultaneously fostering creativity.
2. School administrators and policymakers should provide professional development opportunities for teachers to deepen their understanding and skills in differentiated instruction and open problem solving.
3. Future research is recommended to test the DL-OPS model in different educational contexts, grade levels, and larger samples to strengthen its generalizability and scalability.
4. Researchers are encouraged to further explore the integration of DL-OPS with technology-enhanced learning environments to maximize its potential in 21st-century education.

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