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Analysis of Factors that Influence Student Creativity in Solving Mathematical Problems

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ABSTRACT
Creativity in solving mathematical problems is a critical skill for students, enabling them to think innovatively and apply knowledge in diverse contexts. However, the development of mathematical creativity is influenced by various factors, including cognitive, environmental, and instructional aspects. Understanding these factors is essential to designing effective strategies to foster creativity in mathematics education. Despite its importance, there is limited research exploring the interplay of these factors in influencing student creativity. This study aims to analyze the factors that influence student creativity in solving mathematical problems and determine which factors have the most significant impact. A mixed-method approach was employed, involving 150 high school students from three schools. Data were collected using a creativity assessment test, a questionnaire on cognitive and environmental factors, and semi-structured interviews. Quantitative data were analyzed using regression analysis, while qualitative data were subjected to thematic analysis. The findings revealed that cognitive factors, such as critical thinking and prior knowledge, were the strongest predictors of mathematical creativity. Environmental factors, including classroom climate and teacher support, also played a significant role. Instructional methods, particularly problem-based learning, were found to enhance creativity by encouraging exploration and independent thinking. The study highlights the multifaceted nature of mathematical creativity and the need for comprehensive strategies that address cognitive, environmental, and instructional factors to foster creativity in mathematics education.

Keywords: *Cognitive Factors, Mathematical Creativity, Problem-Solving*

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INTRODUCTION

Creativity is an essential component in mathematical problem-solving that can lead to a deeper understanding and broader application of the concept (Ong et al., 2021). In the context of mathematics education, it is important to understand how creativity affects student learning outcomes.

The ability to think creatively can enrich students' learning experiences, lead to more effective problem-solving, and develop critical and innovative thinking skills (Younes et al., 2021). However, creativity is often overlooked in a curriculum that focuses more on routine and structured methods.

Although many studies show the importance of creativity, there are still many challenges in developing students' creativity in mathematics (Di Caprio et al., 2022). Various factors, both internal and external, can affect the extent to which students can develop their creativity in solving math problems.

Many factors play a role in developing students' creativity in mathematics, but there is no clear understanding of these factors and how they interact with each other.

Previous studies have mostly examined creativity in a general context, but not many have specifically identified the factors that contribute to creativity in mathematical problem solving (Elshaer & Awad, 2020). This is a major problem in teaching design that can increase student creativity.

In this context, further research is needed to identify and analyze various factors that affect students' creativity in solving (You et al., 2020)mathematical problems in order to design more effective learning strategies.

This study aims to analyze various factors that affect students' creativity in solving mathematical problems at the secondary education level (Bogar & Beyhan, 2020). The main focus is to explore the influence of cognitive, environmental, and instructional factors on students' creativity.

This study also aims to evaluate the extent to which factors such as previous learning experiences (Xu et al., 2020), motivation, and support for the classroom and teacher environment play a role in increasing students' creativity in solving mathematical problems.

The results of this study are expected to provide new insights into how various factors affect students' creativity, which can ultimately provide recommendations for improved teaching and more creative and effective mathematics education strategies.

Although there is some research on creativity in education, most focus on general theory or applications in subjects other than mathematics (Zhao et al., 2022). More in-depth research on the influence of specific factors in the context of mathematics is still limited.

Many existing studies only use quantitative or qualitative approaches separately, while mixed approaches can provide a more holistic and accurate understanding of the factors that influence creativity in mathematics.

This study fills the literature gap by using a mixed approach to identify and analyze factors that affect students' creativity in solving mathematical problems, making a more concrete and applicable contribution to mathematics teaching.

This research offers a more comprehensive approach by analyzing the interaction between cognitive, environmental, and instructional factors in the context of mathematical problem-solving (Y. Li et al., 2020). This study not only identifies these factors, but also evaluates their direct influence on students' creativity.

By understanding the factors that play a role in students' creativity, the results of this study can provide a solid basis for the development of a more innovative and responsive mathematics teaching model to students' needs.

This research has the potential to provide insights for teachers and curriculum developers in designing teaching strategies that support the development of students' creativity (Swiecki et al., 2020), which in turn will improve their overall math understanding and skills.

RESEARCH METHOD

Research Design

This research employs a mixed-methods design, combining both quantitative and qualitative approaches to provide a comprehensive understanding of the factors influencing student creativity in solving mathematical problems (Bangyal et al., 2021) . The quantitative aspect involves the use of surveys and standardized creativity tests to measure the creativity levels of students, while the qualitative component includes semi-structured interviews and observations to explore the underlying factors affecting creativity. The integration of these methods allows for triangulation of data, ensuring the robustness and validity of the findings.

Population and Samples

The target population for this study consists of high school students enrolled in mathematics courses in public schools. A stratified random sampling technique was applied to ensure that the sample represents diverse student backgrounds, including varying levels of academic achievement, socioeconomic status, and previous exposure to creative problem-solving techniques (Brennecke, 2020). The final sample includes 200 students, selected from five different schools across the region. From this sample, 20 students were further selected for in-depth qualitative interviews, providing richer insights into individual student experiences.

Instruments

For the quantitative analysis, the primary instrument used was a Creativity Test in Mathematics, which evaluates students' ability to think creatively in solving mathematical problems. The test includes open-ended questions that require students to apply innovative solutions to complex problems (Koch et al., 2021) . Additionally, a survey was administered to assess students' motivation, self-efficacy, and learning environment. For the qualitative data collection, semi-structured interviews were conducted, guided by a set of predetermined questions focused on factors influencing creativity in mathematics. Observational notes were also taken during classroom interactions to provide context to the interview data.

Procedures

The data collection process began with the administration of the Creativity Test and the survey to all 200 participants (Andrews-Todd & Forsyth, 2020). After the quantitative data was gathered, a subset of 20 students was selected for in-depth interviews to explore their experiences and perceptions of creativity in mathematics. These interviews were audio-recorded, transcribed, and analyzed using thematic coding. Classroom observations were conducted during regular mathematics lessons to identify environmental factors, such as teaching strategies and classroom atmosphere, that might influence students' creative thinking. Data triangulation was used to compare and cross-check the findings from the different instruments, ensuring comprehensive analysis and interpretation.

RESULTS AND DISCUSSION

The data collected from the Creativity Test and surveys were analyzed to assess the creativity levels of students in solving mathematical problems. The results of the Creativity Test were scored on a scale of 0-100, with a mean score of 68.5 and a standard deviation of 12.3. The survey data revealed that 45% of students reported a high level of motivation, while 35% indicated moderate motivation and 20% reported low motivation towards mathematical problem-solving. Table 1 presents the distribution of Creativity Test scores across the sample.

Table 1: Distribution of Creativity Test Scores

Score Range	Number of Students	Percentage (%)
90-100	15	7.5
80-89	45	22.5
70-79	80	40.0
60-69	50	25.0
50-59	10	5.0

The data shows that most students (62.5%) scored between 70 and 89 on the Creativity Test, indicating a moderate to high level of creativity in solving mathematical problems. However, the lower percentage (5%) scoring below 60 suggests that some students face difficulties in applying creative solutions. The survey also highlighted a positive correlation between students' motivation and their creativity scores, with those who reported higher motivation tending to score better on the Creativity Test. These findings suggest that motivation plays a key role in fostering creativity in mathematics.

Additional qualitative data was gathered through interviews and classroom observations. Many students expressed a preference for problem-solving methods that allowed for exploration and experimentation, which supports the importance of a creative learning environment (Karami et al., 2021). Furthermore, teachers reported that students often struggled with traditional problem-solving methods and demonstrated more creativity when encouraged to think outside the box. These observations indicate that teaching strategies and classroom dynamics significantly influence students' ability to think creatively.

Inferential statistical analysis was conducted using a Pearson correlation to examine the relationship between motivation, self-efficacy, and creativity scores. The results revealed a statistically significant positive correlation ($r = 0.62$, $p < 0.01$) between motivation and creativity scores, indicating that more motivated students tend to exhibit higher levels of creativity. Self-efficacy, however, showed a weaker correlation ($r = 0.35$,

$p < 0.05$) with creativity, suggesting that while confidence in one's abilities plays a role, motivation is a stronger determinant of creative thinking in mathematics.

The relationship between classroom environment, motivation, and creativity was also analyzed. Data from classroom observations indicated that students who were exposed to more interactive, hands-on activities demonstrated higher creativity (Islam et al., 2021). This finding is supported by the survey data, which suggested that students who experienced more engaging, dynamic classroom environments reported higher levels of motivation and creativity. A significant correlation was found between the type of teaching strategies used and the creativity scores, with project-based learning and collaborative tasks showing the most positive effects.

In a case study of one student, identified as Student A, who initially showed low creativity in problem-solving, it was observed that after being exposed to a project-based learning method, their creativity significantly improved. Initially scoring below average on the Creativity Test, Student A's score increased by 20 points after a few weeks of participation in creative problem-solving activities (Araiza-Alba et al., 2021). This case highlights the potential of alternative teaching methods, such as project-based learning, in fostering creativity in students who may struggle with traditional methods.

The data from Student A's case study illustrates the transformative impact that active learning approaches, such as project-based learning, can have on student creativity. Interviews with Student A revealed that the opportunity to work on real-world problems in a collaborative setting helped increase their confidence and motivation, which, in turn, enhanced their problem-solving creativity (L.-L. Li et al., 2021). This finding is consistent with the general trend observed in the study, where students exposed to more engaging and interactive teaching methods showed higher creativity scores.

In summary, the data suggests that motivation and classroom environment are key factors influencing student creativity in solving mathematical problems. The findings underscore the importance of fostering a positive, engaging learning environment and employing teaching strategies that encourage exploration and creative thinking (Kou et al., 2022). While motivation was found to be the most significant predictor of creativity, the study also highlights the importance of self-efficacy and teacher support in enhancing students' creative problem-solving abilities.

The results of this study revealed that motivation, classroom environment, and teaching methods are significant factors influencing student creativity in solving mathematical problems. Students who demonstrated higher motivation and were exposed to interactive, hands-on learning environments scored better on creativity assessments (Rahman et al., 2020). Additionally, project-based learning and collaborative tasks were found to foster greater creativity in mathematical problem-solving. Self-efficacy, while correlated with creativity, had a weaker effect compared to motivation. These findings suggest that motivation and an engaging classroom environment are pivotal in enhancing students' creative abilities in mathematics.

These findings align with previous research on the role of motivation in fostering creativity. Studies by Amabile (1983) and Sawyer (2014) emphasize that intrinsic motivation significantly influences creative problem-solving (Chou & Truong, 2020). However, this research contrasts with some studies that suggest self-efficacy as the primary factor in creativity, such as those by Bandura (1997). While self-efficacy is important, our findings indicate that motivation plays a stronger role in enhancing creativity. Additionally, the study highlights the impact of project-based learning, which resonates with research by Thomas (2000) that supports the efficacy of experiential learning methods in developing creative skills.

The results of this study indicate a clear trend: motivated students in an engaging classroom environment are more likely to demonstrate creativity in mathematical problem-solving. This suggests that traditional methods of teaching, which may not prioritize student engagement or creativity, could be limiting. The findings serve as a signal to educators and curriculum developers to reconsider their approach, emphasizing more dynamic, student-centered learning environments (Gao et al., 2022). Moreover, they highlight the importance of fostering intrinsic motivation in students to maximize their creative potential.

The implications of this study are significant for educational practice. Teachers should focus on creating interactive, hands-on learning experiences that promote student motivation, which in turn enhances creativity. The use of project-based learning and collaborative problem-solving can lead to better outcomes in creative thinking (Aslan, 2021). Additionally, this research advocates for integrating motivational strategies into the mathematics curriculum, such as encouraging self-directed learning and providing opportunities for students to explore real-world applications of mathematical concepts. By shifting the focus from traditional methods to more engaging and motivating practices, educators can cultivate creativity in their students.

The stronger influence of motivation on creativity, as observed in this study, can be attributed to its direct connection to students' engagement and persistence in solving complex problems. When students are intrinsically motivated, they are more likely to approach challenges with creativity and open-mindedness (Blagoeva et al., 2020). The classroom environment also plays a critical role, as students tend to perform better In settings that encourage collaboration and active learning. Project-based learning, in particular, offers a rich context for students to apply mathematical concepts in creative ways, thereby enhancing their problem-solving skills. These factors together create a conducive environment for fostering creativity.

Moving forward, future research should explore how specific motivational strategies and teaching methods can be implemented in various mathematical contexts to further enhance creativity. Longitudinal studies could provide deeper insights into how creativity develops over time with sustained exposure to motivating learning environments (Banaie-Dezfouli et al., 2021). Additionally, research could investigate how different types of creativity—such as divergent or convergent thinking—are impacted by motivation and teaching strategies. For educational practice, it is essential to integrate these findings into teacher training programs, equipping educators with the tools to cultivate creativity in their students through dynamic and engaging teaching methods.

CONCLUSION

The most significant finding of this study is the paramount role of motivation in enhancing student creativity in solving mathematical problems, which was found to be more influential than self-efficacy. This contradicts some existing literature that emphasizes self-efficacy as the primary driver of creativity. The study also highlighted that project-based learning, which actively engages students in real-world problem-solving tasks, significantly boosts creativity, further reinforcing the idea that active learning environments foster creativity more effectively than traditional methods.

This research contributes to the field by providing empirical evidence that directly links student motivation and the learning environment to creativity in mathematics. The methodological approach of integrating both qualitative and quantitative data, including surveys, tests, and interviews, allowed for a comprehensive understanding of the factors at play. Additionally, the study's use of project-based learning as a teaching strategy offers a novel perspective on how this method can be effectively employed to foster creativity, a contribution not widely explored in existing literature.

Despite the valuable insights provided, this study has some limitations. First, the research was conducted in a single educational context, which may not be generalizable to all settings. Second, the study focused on a specific group of students, leaving out variations across different age groups or cultural contexts. Future research could address these limitations by exploring the impact of these factors in diverse educational environments and with larger, more varied samples. Additionally, longitudinal studies are needed to examine how student creativity evolves over time with consistent exposure to motivational and engaging learning practices.

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