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EXPERIMENTAL STUDY OF THE IMPACT OF INNOVATIVE TEACHING PREPARATION ON THE DEVELOPMENT OF CREATIVITY IN PRIMARY MATHEMATICS TEACHING

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Abstract: Teaching mathematics in the early grades with innovative and problem-based tasks stimulates students' creativity, motivation and interest in learning. The aim of this paper is to examine the impact of innovative teaching methods on the development of creativity in younger school-age students. The research was conducted in the third grade of primary school with 128 students during 30 experimental lessons. The experimental program fully followed the current mathematics curriculum and included 30 experimental lessons. The teaching areas used for the purposes of this research are: Addition and subtraction of numbers up to 100, Multiplication and division of numbers up to 100 and Measurement and measurement. The experimental program included teaching units, aligned with the current curriculum. The teaching units were designed to encourage the development of creativity and application of teaching content through a variety of problem-solving tasks. The tasks on the final tests were structured according to the content of the teaching units from the three teaching areas listed above. Each lesson was implemented by presenting an unusual contextual-research situation that was stimulating in the creative solution of complex mathematical problems (an interesting story with an interesting message), textually relevant scenes from children's films. Students independently solved prepared program-relevant complex mathematical problems. Students were systematically monitored and provided with teacher support when solving problems in conditions of increased curiosity and an emotionally pleasant atmosphere. The structure of the experimental program is based on theoretical foundations and experimental findings. When choosing and constructing a problem-based mathematical task in mathematics, the experimenter respected previous studies on problem-based and research-based teaching, and especially on the requirements that each such task has a hidden unknown that the student should discover through the inventive application of previous thematically relevant mathematical knowledge and through intensive cognitive and creative activity.The results show that the use of problem-based tasks in teaching significantly stimulates creativity, flexibility of thinking and motivation of students for learning mathematics. The results of the experimental program indicate its potential as a practical support for teachers in stimulating creative thinking in younger school-age students.

Keywords: creativity, problem-solving tasks, creative mathematical problem-solving test, experimental teaching
Field: Social Sciences

1. INTRODUCTION

Mathematics, as a scientific discipline and intellectual field, is at the very top of the hierarchical list when it comes to the presence of creativity in its activities or results (Mihajlović, 2023 , Vasiljević, 2024). Problem solving from an early age encourages originality, flexibility, fluency and elaboration in students (Filek, 2021). Research shows that open-ended problem tasks, which allow for multiple solutions and reasoned discussion, significantly contribute to the development of mathematical creativity (Becker, 1997, Svitek, 2022). According to Kwon, Park (2020), mathematical creativity is reflected in the creation of new knowledge and flexible problem solving. Dejić, Čebić, and Mihajlović (2009) point out that younger children show a greater degree of creativity than older ones, which confirms the importance of early stimulation of creativity in mathematics teaching. The definition of an open-ended problem, however, varies from researcher to researcher. Takahashi (Takahashi, 2001 according to Ja and Fon 2005, p.1) . Closed-ended tasks in primary education allow reproduction of algorithms and checking students' basic knowledge, while open-ended tasks enable discussion, strategy selection, and argumentation of solutions (Nikolić, 2025). Others believe that open- ended tasks enable the development of investigative and creative thinking (Svitek, 2022).

Mathematical creativity is usually described as insight or "choice" (Poincare, 1948, according to Sriraman, 2004). Kwon, Park, and Park (2006) proposed two main criteria in defining mathematical creativity: the creation of new knowledge and the flexible ability to solve problems.

Modern research confirms the importance of these components and further emphasizes the role of the teaching approach in the development of creativity. Thus, Leikin and Sriraman (2022) point out

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that different problem-solving strategies directly develop mathematical creativity. Research conducted by Elgrable and Leikin (2021) shows that creativity in mathematics is closely related to the level of expertise in problem solving. Furthermore, a systematic review by Sipahi and Bahar (2025) confirms that open-ended tasks and research activities have a significant impact on the development of mathematical creativity in students. Similarly, Lu, Kaiser, and Zhu (2025) emphasize the role of mathematical modeling and encouraging creative thinking. Also, Mann and Chamberlin (2025) indicate that the application of modern teaching strategies significantly improves students' creativity in elementary mathematics education.

Recent studies provide additional support and deeper insights into the development of mathematical creativity. Leikin and Elgrably (2022) distinguish between strategy creativity and outcome creativity, highlighting the importance of multiple solution paths in open-ended tasks. Ye, Ng, and Leung (2024) emphasize the role of innovative teaching approaches, such as programming-based mathematical activities, in fostering creative engagement. Furthermore, Li and Kim (2024) point to the cognitive and neurological foundations of mathematical creativity, linking it to complex and flexible problem-solving processes. Ron-Ezra and Levenson (2025) confirm that open arithmetic tasks encourage diverse strategies and enhance creativity even among students with learning difficulties. Additionally, Genç et al. (2025) highlight the strong connection between mathematical communication, thinking, and creativity as mutually reinforcing components.

mathematical creativity is a complex and multidimensional construct that includes originality, flexibility, fluency, and the ability to generate and justify multiple solutions. Contemporary research consistently shows that open-ended tasks, problem-based learning, mathematical modeling, and innovative teaching approaches play a crucial role in fostering creativity from an early age. Therefore, integrating such approaches into mathematics education represents a key step towards developing students' higher-order thinking skills and creative potential.

2. METHODOLOGICAL FRAMEWORK OF THE RESEARCH

The subject and problem of the research is an experimental study of written teaching materials in elementary mathematics teaching with a focus on the influence of problem tasks on the development of creativity in younger school-age students. The problem is to determine the effect of these materials on creative thinking and school success.

The aim of the experimental research is to determine the impact of innovative teaching methods on the development, motivation and interest in mathematics, through a test of creative mathematical problem solving.

Research tasks arise from the set research goal :

1. To determine the impact of an experimental program (written preparations) on the development of creativity in younger school-age students in elementary mathematics instruction.

2. To determine the difference in creativity development between the experimental and control groups.

The main hypothesis of the research is : Experimental application of problem-based teaching methods has a positive effect on the development of creativity in younger school-age students.

Auxiliary hypotheses were put forward :

H1.1. The difference in the results of the creative test between the experimental and control groups is statistically significant after the application of innovative preparations.

X1.1. Students in the experimental group will achieve better results in general achievement than the previous grade.

Sample and research variables

The research was conducted in the 2024/2025 school year in a total of 6 classes of the third grade of primary school (128). The experimental group consisted of 64 students, and the control group consisted of 64. The remaining three classes (64 students). The experiment lasted from the beginning of November to mid-December 2024, a total of 30 experimental classes.

Methods and instruments used in this research: creative mathematical problem-solving test, arithmetic mean, Mann – Whitney U test and Chi-square test.

3. RESEARCH RESULTS

Table 1. Results of the E-group and K-group on the creative mathematical problem-solving test

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
1. Initial test (test creative solutions mathematical problem)	2021,000	4101,000	-0.130	0.897
2.Final test (test) creative solutions mathematical problem)	1652,000	3732,000	-1.908	0.046
general success previous class	1673,000	3753,000	-2,102	0.036

Source: author's own research

Hypothesis H1.1. On the initial test of creative mathematical problem solving, no significant difference was found between the groups (r = 0.897). The difference in the results of the creative test between the experimental and control groups is statistically significant after the application of innovative preparations with problem tasks and is confirmed. Mann-Whitney U test for the 2nd Final Test (creative mathematical problem solving test) ($U = 1652.000$, $Z = -1.908$, $p < 0.05$; $p=0.046$). Since $p < 0.05$, we can conclude that there is a statistically significant difference between the test of creative mathematical problem solving) in relation to the groups (1-Control group/2-Experimental group). Mean Rank 2. The creative math problem solving test for the 1-Control group (58, 31) is statistically significantly different from the Mean Rank for the 2-Experimental group (70, 36). The experimental group has a statistically significantly higher rank. Based on the above, we can conclude that the hypothesis H1.1 is confirmed (not rejected) the difference in the results of the creative test between the experimental and control groups is statistically significant after the application of innovative preparations with problem tasks.

Hypothesis H1.2. Students in the experimental group will achieve better results in general achievement in the previous grade is confirmed.

Table 2. Comparison of control and experimental groups based on overall success

Test	Mann Whitney U	Wilcoxon W	Z value	p- value (Asymp.Sig. 2-tailed)
1.Initial test (creative problem-solving test)	2021,000	4101,000	-0.130	0.897
2. Final test (creative problem-solving test)	1652,000	3732,000	-1.908	0.046
Overall performance in the previous grade	1673,000	3753,000	-2,102	0.036

Source: author's own research

The results of the Mann-Whitney U test indicate that there is a statistically significant difference in the overall success of students between the experimental and control groups ($U = 1673.000$, $Z = -2.102$, $p < 0.05$; $p=0.036$) . The obtained mean rank results show that students in the experimental group achieve better overall success (Mean Rank = 70.36) compared to students in the control group. (Mean Rank =58.64). The application of the experimental program had a positive impact on the overall academic achievement of students, which indicates an integral indicator of academic functioning. If we compare individual grades in a particular subject, overall success is a sensitive category to changes in teaching approaches that stimulate learning, motivation and interest of students. The results of the experimental group as a consequence of the application of innovative teaching methods, enabled students are more active in class and develop the components of creative thinking and a positive attitude towards learning .

4. DISCUSSION

The results confirm that the use of innovative problem-based teaching methods significantly stimulates the creativity of younger students. The experimental group showed greater progress on the creative problem-solving test and better overall success, which supports previous research (Mihajlović, 2012). These results indicate the long-term positive effects of the use of open and closed problem-based teaching methods in mathematics teaching, as they stimulate originality, flexibility and elaboration in students' thinking. The methodological approach also shows that creativity can be systematically developed through structured teaching methods. These findings indicate that the application of innovative teaching methods that involve a variety of problem-based tasks not only affects the acquisition of teaching material, but also the development of cognitive processes such as originality, flexibility and elaboration. It is particularly important that such approaches encourage students to approach the problem from multiple angles, which contributes to a deeper understanding of mathematical content. Also, the observed progress can be attributed to the increased level of student motivation, because problem-based tasks introduce an element of challenge and research into the teaching process. In this way, students do not remain passive recipients of knowledge, but become active learners in its construction. All of the above indicates that problem-based tasks represent a significant didactic tool that can contribute not only to better student achievement, but also to the development of their creative potential through innovative teaching methods.

5. CONCLUSION

Experimental application of problem-based preparation led to statistically significant increases in creativity and overall academic achievement. These results indicate the need for teachers in elementary mathematics education to use innovative and problem-based tasks as a regular part of the teaching. Also, the regular use of innovative teaching methods permeated with a variety of problem-solving tasks encourages the development of critical thinking, analytical skills and independence of students. When students encounter tasks that do not have a simple or standardized answer, they learn how to consider different approaches, evaluate possible solutions and draw their own conclusions. In addition, this approach increases motivation for learning because students see the direct application of mathematics in everyday life, which makes teaching more interactive and meaningful. Given these positive effects, the integration of innovative methodologies such as project-based learning and small group work can further improve academic success, but also the development of creativity, which is crucial for preparing students for more complex tasks in the future. Teachers should therefore plan lessons that stimulate exploration, experimentation, and discussion, creating an environment in which learning mathematics is both challenging and fun.

In conclusion, the consistent implementation of problem-based and innovative teaching strategies not only enhances academic achievement and creativity but also fosters essential 21st-century skills such as critical thinking, problem-solving, and independent learning. By creating a classroom environment that encourages exploration, collaboration, and meaningful engagement with mathematical concepts, teachers can prepare students to approach complex challenges with confidence and adaptability. Therefore, incorporating these methodologies is not just a way to improve immediate learning outcomes—it is an investment in developing lifelong learners who are capable of applying knowledge creatively and effectively in diverse real-world contexts.

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