Časopis za poslovnu teoriju i praksu
Rad primljen: 24.04.2025.
Rad odobren: 05.05.2025.

UDK 159.954/.956-057.874:37.081.315.7
DOI 10.7251/POS2534037L
COBISS.RS-ID 142867969
Originalan naučni rad

Lolić Slađana, doctorand of Faculty of Philosophy, Banja Luka, Bosnia and Herzegovina, lolics537@gmail.com
Stojančić Anđela, Faculty of Economics, Belgrade, Serbia
Lukić Sanja, Walgreens Boots Alliance, London, United Kingdom

THE EFFECTS OF PROBLEM-BASED LEARNING IN ELEMENTARY MATHEMATICS EDUCATION

Summary: New models of effective learning are achieved through the adoption of applicable knowledge that fully engages students' intellectual abilities.
When discussing learning outcomes, it is very important to understand that simply offering solutions is not enough. Teaching emphasizes the acquisition of both general and specific knowledge. Knowledge is acquired in a different way compared to previous educational approaches; students now approach mathematical problem-solving critically, which enables them to observe, consider, and analyze problems using critical and creative thinking, reflection, and problem-solving skills.

Key words: *learning outcomes, problem-based mathematics instruction, problem-based learning*

JEL classification: *M10, M12*

INTRODUCTION

Mathematics is by no means dry, boring, or lacking imagination; on the contrary, like a noble lady, it returns the love of those who understand and cherish it.
— Vladimir Devidè

Mathematics is a significant aspect of human culture, the essence of scientific and technological development, and a wealth that an individual can utilize without limits. It plays an important role in the intellectual development of children, in logical thinking, forming a scientific worldview, and spatial orientation. Elementary mathematics education, in addition to its general educational importance, plays a crucial role not only in the acquisition of basic mathematical concepts, facts, and operations, but also in the development of students' abilities such as observation, analysis, and solving mathematical problems; the ability to compare different ideas and generate new ones; logical reasoning; abstract thinking; and drawing conclusions.
The title itself implies a commitment to research that presents a problem-based approach to learning (problem-based learning, working on problem-solving tasks) within the content of elementary mathematics instruction. It is important to further develop mathematical and scientific communication in self-directed learning, cognition, metacognition, and classroom

motivation. Greater use of mathematical knowledge should be made in simulated classroom situations that resemble real-life scenarios where mathematical competencies are applied. This also includes the development of students' metacognitive abilities during reasoning and problem-solving in mathematical contexts.

The effects of early mathematics education must not be overlooked. These are reflected in fostering responsibility in work, a culture of independent study, critical thinking, precision, neatness, systematic approach, and step-by-step learning. All these aspects of early mathematics instruction form the foundation for mastering mathematical content and continued learning.

1. LEARNING EFFECTS

Mathematics is simply a way of describing relation between numbers and other measurable quantities. It can express simple equations, but also the interactions between the smallest particles and the most distant objects in the known universe. Mathematics enables scientists to communicate ideas using universally accepted terminology (Zakariya 2015).

Learning effects refer to the success in achieving the goals and objectives of education. Among the many factors that influence the effectiveness of the educational process, two are most important: the nature of the educational process itself and the subject of education—that is, learning and its role and position within the educational process. The educational process becomes more effective through the acquisition of knowledge based on critical thinking, reflection, and problem-solving, which maximally engages students' intellectual abilities. The effectiveness of the educational process is also determined by how much of the acquired knowledge becomes the student's lasting possession and whether they are able to practically apply it in new real-life situations. The process of managing one's own knowledge helps students solve mathematical problems (Boaler 1998).

Most studies show a positive impact of problem-based learning on mathematics education. A positive effect was observed for both gender categories (Ajai and Imoko 2015). However, female students retained the knowledge longer compared to their male peers.

Educational effects refer to the outcomes and results achieved in the process of upbringing and education, i.e., the effects on the intellectual, moral, emotional, work-related, physical, and aesthetic development of the learner's personality, as well as their behavior and actions within this process. The efficiency of the educational process means the degree of success of each pedagogical measure undertaken in the process of upbringing and education. The criteria for evaluating effectiveness may vary: the amount of knowledge, skills, and habits acquired; their quality, intensity, and impact on positive behavioral changes in the learner.

The idea of education as mere transmission of ready-made information and building certain exactitudes has been surpassed. The ultimate goal is for the student to acquire knowledge through their own efforts, since the educational process in schools should focus on the student's creative work, supported by the teacher. In this paper, the effects are operationalized through the research process of solving problem-based situations and tasks.

2. PROBLEM-BASED MATHEMATICS INSTRUCTION

Problem-based instruction and the system of problem-based teaching represent the response of psychological and pedagogical sciences in the search for more effective teaching—i.e., a more effective instructional system.

Problem-based learning describes a learning process in which problems initiate learning—meaning, learning begins with a problem that needs to be solved. The problem is presented in such a way that students must acquire new knowledge before they can solve it. In this process, students interpret the problem, gather necessary information, identify possible solutions, evaluate options and conclusions.

With the introduction of problem-based learning, the teacher's role is to give students the opportunity to discover mathematics through inquiry. In all cases, learning mathematics should begin by introducing problems that are relevant to the students' real-life situations (contextual problems).

The problem-based learning model is an effective method for addressing the challenges of the 21st century. Students work collaboratively in groups to solve problems. The teacher's role is to facilitate learning by giving guidance or posing questions that stimulate students to arrive at temporary or final solutions through a thinking process.

Problem-based learning requires not only mutual interaction between student and student, and student and teacher, but also a high level of responsibility for one's own work, communication, collaborative relationships, inquiry, critical thinking, creativity, and reflection—while respecting each group member and supporting their ideas and contributions.

The ability to solve a problem effectively is one of the most valued traits in the world (Puji Ati and Setiawan 2020, 297).

Responsibility for the entire learning process must also include the freedom to make decisions necessary to carry out that process (Tatic and Haracic and Haracic 2018, 32). The role of the student changes through solving problem-based tasks and situations. The student investigates, asks questions, gathers new evidence, expresses opinions using arguments, considers other perspectives, understands causes and effects, applies independent and self-directed thinking, generates new and innovative ideas, makes evidence-based decisions, draws conclusions, and solves problems. A creative student should think wisely, but also be flexible and open to different alternatives. This approach requires greater engagement from the student, and through that engagement, they find creative solutions to problems.

The Problem-Based Learning (PBL) model is suitable for increasing students' creativity, as during the learning process students are presented with problems related to real-life situations to stimulate creative thinking (Rizkia 2017). It can also significantly improve student achievement in mathematics and contribute to the development of a positive attitude toward learning mathematics. Furthermore, this model of learning has been shown to be more effective than traditional problem-solving approaches for developing critical thinking skills in fifth-grade students in mathematics learning (Puji Ati and Setiawan 2020, 294).

3. RESEARCH METHODOLOGY

The problem addressed in this research relates to problem-based learning in mathematics instruction. The subject of the research is focused on examining the effects of applying a problem-based approach to learning in early mathematics education.

The aim of the research is to determine the level of educational achievements among younger school-age students as a result of using a problem-based approach to learning in elementary mathematics instruction.

To address this aim, the research was further specified through the following tasks:

Research tasks:

1. To assess the achievements of younger school-age students who have mastered mathematical content through a problem-based learning approach, in terms of understanding basic mathematical concepts, compared to those taught using traditional instruction.
2. To determine whether students who have acquired mathematical content using a problem-based approach will achieve a statistically significant level of performance in logical thinking compared to students taught through conventional traditional methods.

The sample consisted of students from eight classes in two primary schools in the city of Banja Luka (Elementary School "Ivo Andrić" and Elementary School "Branko Ćopić"). Four classes from each school participated in the research. Two classes from each school formed the experimental group, and two formed the control group. Both the experimental and control groups were observed as whole units, with 95 students in each group.
Both groups were informed in advance that a knowledge assessment covering content from the previous school year would be conducted. Naturally, the students' performance was influenced by the revision of previously learned material.
Table 1 presents the results related to basic mathematical concepts between the control and experimental groups. The test included 10 tasks covering the following areas:

- Understanding of natural numbers
- Writing numbers presented in word form
- Rules of basic arithmetic operations (associativity, commutativity)
- Calculating expressions involving addition, subtraction, multiplication, and division
- Solving equations and inequalities, and identifying the sets of numbers that are solutions to inequalities
- Comparing units of measurement
- Drawing basic geometric shapes
- Recognizing types of geometric figures (triangles, quadrilaterals)

Students in both the control and experimental groups were given the test during a full class period (45 minutes). To reduce the influence of the regular class teacher during the assessment, the teachers were assigned to supervise a different classroom during test administration, thereby minimizing the possibility of assistance being provided to the students.

Table 1. Knowledge of Basic Mathematical Concepts by Group (Authors)

Grupa	N	M	SD	t - test	df	Sig.
K	95	25,13	8,48			
E	95	27,45	8,41	-1,9	188	0,059

Based on the data presented in the table, it is observed that students in the control group achieved a mean score of M = 25.13, which is lower than the mean score of the students in the experimental group. When comparing the standard deviation values for both groups, it can be seen that the level of homogeneity in terms of knowledge of basic mathematical concepts is approximately the same for both groups. Students in the experimental group achieved higher average results, with a mean score of M = 27.45.
Based on the value of $t = -1.9$, with degrees of freedom $df = 188$ and a significance level of *Sig.* = 0.059, it is concluded that there is no statistically significant difference between the performance of students in the control and experimental groups in terms of their knowledge of basic mathematical concepts. This test is important because mastering basic mathematical concepts is essential for continuing with the mathematics curriculum in the fifth grade.
It was assumed that students in the experimental group would achieve statistically higher results compared to the control group. However, the results showed that students in the experimental group did not achieve statistically significantly higher results. This may be due to the teaching methods used in the control groups, since the content of tasks during the introduction, practice, and reinforcement of new material could not be fully controlled. Looking at the significance level (*Sig.* = 0.059), it can be concluded that a statistically significant difference does not exist primarily due to the digit 9 in the thousandths place, indicating that the result is on the borderline of the significance threshold of 0.05.
The reason for such results may lie in the specific nature of mathematical content in general. The textbooks used for mathematics instruction are designed to include both word problems

and problem-solving tasks across all thematic units. Therefore, such tasks may have had an impact on the performance of students in the control group.
The second research task was to determine whether younger school-age students who mastered content using a problem-based learning approach in early mathematics instruction would achieve a statistically significant level of performance in terms of logical mathematical thinking, compared to traditional instruction. This test also assessed knowledge that students could and should have acquired in the previous school year. In the first math classes, content from the previous grade was reviewed. As with the previous test, both groups of students were informed in advance that an assessment of previously learned material related to mathematical logical thinking would be conducted.

Table 2 presents the results in mathematical logical thinking for students in the control and experimental groups (Authors)

Grupa	N	M	SD	t - test	df	Sig.
K	95	11,21	3,43			
E	95	11,57	2,66	-0,80	188	0,423

Students in the experimental group achieved a slightly higher average score on the Mathematical Logical Thinking Test, with a calculated mean of M = 11.57, compared to the control group, whose average score was lower, at M = 11.21. Based on the standard deviation, which was lower in the experimental group (SD = 2.66), it can be observed that their knowledge was more homogeneous than that of the control group.
According to the established statistical indicators (*t* = -0.80, *df* = 188, and *Sig.* = 0.423), it is concluded that there is no statistically significant difference between the performance of students in the control group and those in the experimental group.
The Mathematical Logical Thinking Test is important because the ability to think logically—especially in mathematics—is crucial for the application of problem-based learning and the successful solving of problem-oriented and investigative tasks.

CONCLUSION

Mathematics is an extremely important subject as it forms the foundation for many other subjects in primary, secondary, and later in higher education. Therefore, the ability to apply mathematical knowledge is of great pedagogical significance. The development of such abilities can be significantly supported through high-quality early mathematics instruction.
The results of the research indicate that problem-based learning had a positive effect and motivational impact on the learning of mathematical content in early fifth-grade instruction.
The implementation of the experimental program showed that students in the experimental group achieved a higher mean score on the test measuring knowledge of basic mathematical concepts. Based on the statistical indicators (*t* = -1.9, *df* = 188, *Sig.* = 0.059), it is concluded that there is no statistically significant difference between the performance of the control and experimental groups in terms of basic mathematical knowledge.
When it comes to the level of mathematical logical thinking, students in the experimental group achieved a slightly higher mean score. However, according to the statistical indicators (*t* = -0.80, *df* = 188, *Sig.* = 0.423), it is also concluded that no statistically significant difference exists between the control and experimental group in this regard.
The effects of applying problem-based learning in mathematics instruction demand greater cognitive engagement and higher student motivation. In this study, this was achieved through a problem-based approach to learning early mathematics content and solving problem-oriented and investigative tasks.

The findings of this research are highly valuable and can be used by various stakeholders to develop new approaches to instructional practices—not only in early mathematics education, but in broader educational contexts as well.

REFERENCES

1. Ajai, John, and Imoko, Benjamin. 2015. "Gender differences in mathematics achievement and retention scores: A case of problem based learning method". *International Journal of Research in Education and Science* 1(1):45- 50.
2. Boaler, Jo. 1998. "Open and Closed Mathematics Approaches: Student Experiences and Understandings". *Journal for Research in Mathematics Education* 29 (1): 41-62. https://doi.org/10.5951/jresematheduc.29.1.0041
3. Tatic, Kasim, Mahir Haracic, and Merima Haracic. 2018. "The Improvement of Business Efficiency Through Business Process Management." *Journal of Economics and Business* 16(1): 31-43.
4. Puji Ati, Tri, and Setiawan Yohana. 2020. "Efektivitas problem based larning problem solving". *Jurnal Cendekia: Jurnal Pendidikan Matematika* 4(1): 294-303. https://doi.org/10.31004/cendekia.v4i1.209
5. Rizkia, Sofri. 2017. "The influence of ethnomathematics - contained problem based learning model and mathematical disposition skill toward mathematical representation". *Mathematics Education Journal* 1(2): 8-17.
6. Zakariya, Yusuf. 2015. Investigation into the Causes of Poor Academic Performance in Mathematics among Nigerian Undergraduate Students. *World Journal of Social Sciences and Humanitie* 1(1): 1–5.