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Picture Book as a Stimulus for Mathematical Creativity in Primary Education

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POVZETEK – V raziskavi smo preučili, kako lahko slikanica služi kot spodbuda za razvoj matematične ustvarjalnosti pri nadarjenih učencih nižjih razredov osnovne šole. Štirje učenci so sodelovali v treh delavnicah, ki so temeljile na slikanici Brojalica (The Counting Book, Donaldson & King-Chai, 2021) in v okviru katerih so ustvarjali nove matematične naloge. Analiza učenčevih izdelkov in izjav je pokazala postopni prehod od reproduktivnega razmišljanja k ustvarjalnemu ter razvoj fleksibilnosti, fluentnosti, izvirnosti in metakognitivne zavesti. Učenci so matematiko začeli doživljati kot prostor igre, raziskovanja in domišljije in ne le kot sistem iskanja pravilnih rešitev. Slikanica je bila učinkovito izhodišče, ki povezuje zgodbo, podobo in število ter ustvarja čustveni kontekst, v katerem se razvijata motivacija in občutek smisla. Rezultati potrjujejo, da se matematična ustvarjalnost ne razvija spontano, temveč skozi metodično vodene dejavnosti, ki učencem omogočajo svobodo razmišljanja in izražanja. Takšen integrirani pristop prispeva k razvoju pozitivnega odnosa do matematike ter spodbuja učence, da se doživljajo kot ustvarjalce znanja, kar predstavlja pomembno usmeritev za prihodnjo pedagoško prakso.

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ABSTRACT – This research examined how a picture book can serve as a stimulus for developing mathematical creativity among gifted lower primary school students. Four students participated in three workshops based on the picture book Counting Creatures (Donaldson & King-Chai, 2021), during which they created their own mathematical tasks. The analysis of the students' work and statements revealed a gradual shift from reproductive to creative thinking, as well as the development of flexibility, fluency, originality, and metacognitive awareness. The students began to perceive mathematics not as a system of correct answers, but as a space for play, exploration, and imagination. The picture book proved to be an effective starting point that connects story, image, and number, creating an emotional context, in which motivation and a sense of meaning can develop. The results confirm that mathematical creativity does not develop spontaneously, but through methodically guided activities that offer freedom of thought and expression. Such an integrated approach contributes to the development of a positive attitude toward mathematics and encourages students to see themselves as creators of knowledge, which represents an important guideline for future teaching practice.

1 Introduction

Mathematical Creativity – Concept and Features

Creativity in mathematics is considered one of the highest cognitive competencies, as it involves the ability to generate new and valuable ideas within a mathematical context (Leikin, 2009; Silver, 1997). In contrast to the conventional view of mathematics as a discipline with a single correct answer, contemporary research emphasizes that creative mathematical thinking entails flexibility, fluency, and originality (Mann, 2006;

Runco & Acar, 2012). Creativity does not refer exclusively to the discovery of new theorems, but also to students' ability to connect concepts, explore different approaches to problem-solving, and pose their own questions – which is often manifested through multiple solution paths and the creation of new tasks (Leikin & Pitta-Pantazi, 2013). Recent systematic reviews additionally emphasize that creativity in mathematics education is a multidimensional and theoretically diverse construct, encompassing creative products, processes, personal characteristics, and sociocultural influences (Joklitschke et al., 2022). Sriraman (2005) distinguishes between two levels of mathematical creativity: one that is expressed through students' classroom creativity, and another that is characteristic of professional mathematicians. At the professional level, mathematical creativity is defined as the ability to produce original work that significantly extends the existing knowledge or opens new research questions, while at the student level, it refers to a process resulting in unusual, insight-rich solutions or new ways of perceiving familiar problems (Sriraman, 2005, p. 24). The author points out that creativity in the school context emerges at the "edges" of gifted students and emphasizes the need to create an environment that fosters the development of such creativity, thereby bridging the gap between student and professional levels of mathematical creation (Sriraman, 2005, p. 29). Creativity develops when students are given the opportunity to reflect, experiment, and create in a safe environment that accepts error as an integral part of the process (Sternberg, 2003; Beghetto & Kaufman, 2014). According to Levenson (2013), open-ended tasks play a crucial role, as they stimulate divergent thinking – the ability to generate multiple possible answers to a single question. Such tasks not only develop cognitive flexibility but also metacognitive awareness – students reflect on their own processes, compare strategies, and evaluate the effectiveness of their thinking (Bolden et al., 2010; Lithner, 2008). Research on creativity-directed mathematical tasks further highlights the importance of open-ended activities, visualizations, communication, extensions, and problem-posing opportunities in promoting students' mathematical creativity (Bicer et al., 2021). On the other hand, traditional textbook tasks often limit creativity, because they offer predetermined paths and unambiguous answers (Krutetskii, 1976; Sheffield, 2013). The analyses of middle school mathematics curricula demonstrate that creativity-oriented tasks are still underrepresented in many textbooks, with procedural and closed problems continuing to dominate the classroom practice (Bicer et al., 2021). Such practice is particularly restrictive for above-average and gifted students, who, due to constant work on closed tasks, may develop reproductive rather than creative strategies (Leikin, 2009). Therefore, contemporary approaches increasingly emphasize the need for creatively structured activities that allow students to create, interpret, and combine mathematical ideas. In geometry education, creativity is particularly associated with flexibility in perceiving geometrical figures, constructing auxiliary lines, and generating multiple solution paths, all of which contribute to fluency, flexibility, and originality in mathematical thinking (Gridos et al., 2022). Furthermore, rigorous mathematical thinking, especially through mathematical proof, is considered closely connected to conceptual understanding and reasoning processes that support higher-order mathematical creativity (Firmasari et al., 2022). Contemporary studies also emphasize that digital environments, including digital game-based learning and STEM-oriented approaches, may foster creative and critical mathematical thinking by providing students with opportunities for exploration, experimentation, and authentic problem-solving (Al-Barakat et al., 2025; Suherman et al., 2021).

Creating Mathematical Tasks (Problem Posing)

One of the most important strategies for developing mathematical creativity is creating tasks, known as problem posing (Silver & Cai, 2005). This process involves formulating new mathematical problems, transforming existing ones, and designing situations that require mathematical thinking. According to Silver (1994) and Cai and Hwang (2019), problem posing not only fosters creative thinking but also deepens conceptual understanding, as students must actively determine which relationships, quantities, and operations are relevant in a given context. More recent research additionally emphasizes that problem posing should be viewed as an essential mathematical practice and an important component of curriculum redesign, rather than merely an occasional enrichment activity (Cai & Hwang, 2021).

Cai and Hwang (2019) identify three developmental stages in mastering this skill:

1. Reproduction of familiar patterns – students imitate already existing tasks;
2. Modification – students change numbers, conditions, or the context of the problem;
3. Creation – students design entirely new tasks.

These stages do not represent a strict sequence, but rather a dynamic process that demonstrates how a student progresses from imitation toward originality. When students create their own tasks, they face complex cognitive demands: they must identify mathematical structures, recognize possible variables, and anticipate potential solutions. Such a process fosters the development of metacognitive control, as students plan, predict, and evaluate their own thinking processes (Kontorovich et al., 2012; Leikin, 2009). Cankoy (2014) emphasizes that problem posing is one of the most powerful methods for working with gifted students, as it encourages them to move beyond textbook mathematics and assume the role of knowledge creators. However, research shows that most students initially produce formulaic and closed tasks, closely resembling those found in textbooks (Kontorovich et al., 2012; Silver & Cai, 2005). This confirms how strongly educational systems are oriented toward accuracy rather than creativity. Only when students are provided with a supportive, non-normative, and stimulating environment do they begin to exhibit cognitive flexibility and originality (Cai & Hwang, 2019; Leikin & Pitta-Pantazi, 2013). Studies focusing on multiple-solution problem solving further demonstrate that opportunities to create and reformulate tasks contribute to students' flexibility, originality, and deeper structural understanding of mathematical concepts (Gridos et al., 2022). For students with pronounced mathematical abilities, creating tasks has an added value: it fosters a sense of ownership over their learning (Mann, 2006) and develops their mathematical identity – the perception of themselves as individuals who not only solve but also 'build' mathematics. This shift from passive reproduction to active creation is regarded as the foundation of creative self-confidence (Sriraman, 2009). Additionally, teacher support plays an important role in this process, particularly through questioning strategies that encourage students to interpret, explain, evaluate, and justify their mathematical thinking (Monteleone, 2022). Recent studies also indicate that computational thinking and digital environments can support students' creative mathematical engagement by encouraging abstraction, decomposition, algorithmic reasoning, and exploratory learning approaches (Walton et al., 2022).

Picture Book and Narrative as a Stimulus for Mathematical Thinking

Interdisciplinary approaches, particularly those that connect language, art, and mathematics, are gaining increasing importance in contemporary didactics. Picture books, as multimodal texts that integrate visual, verbal, and symbolic codes, have proven to be extremely useful in stimulating mathematical thinking, especially at an early age (Marston, 2014; van den Heuvel-Panhuizen et al., 2016). According to Shatzer (2008), the picture book functions as a 'bridge"' between the story and number – it contextualizes abstract concepts and enables students to experience mathematics as an integral part of everyday life. Reading and analysing picture books in mathematics instruction encourage children to actively observe, compare, and classify, processes that form the foundation of mathematical operations (Whitin & Whitin, 2004). When students examine illustrations, they spontaneously discuss size, quantity, patterns, and spatial relationships, all of which contribute to the development of pre-mathematical and logical concepts (van den Heuvel -Panhuizen et al., 2016). Marston (2014) and Whitin and Whitin (2004) emphasize that such activities connect the emotional and cognitive spheres, as students develop a sense of meaning and aesthetic appreciation in mathematics. From the perspective of mathematical creativity, picture books can also support fluency, flexibility, and originality by encouraging students to interpret visual information in multiple ways and generate diverse mathematical ideas inspired by narrative contexts (Gridos et al., 2022; Joklitschke et al., 2022). Additionally, multimodal and open-ended learning environments provide opportunities for students to engage in exploratory and creative mathematical reasoning rather than merely reproducing predefined procedures (Bicer et al., 2021).

In this study, the picture book Counting Creatures (Donaldson & King-Chai, 2021) serves as a creative starting point: students do not merely extract numbers or motifs from the story but create their own mathematical tasks inspired by its images and narrative. In this way, the picture book is transformed from a medium for learning into a medium for creation, while students develop both the cognitive and aesthetic dimensions of creativity (Beghetto & Kaufman, 2014). Such activities are closely connected to contemporary understandings of problem posing, where students actively formulate mathematical situations, reinterpret familiar contexts, and construct their own mathematical meanings (Cai & Hwang, 2021). Moreover, visual and narrative stimuli can encourage students to generate multiple interpretations and solution strategies, which are considered important indicators of mathematical creativity (Gridos et al., 2022).

Connecting the Three Concepts

By linking the concepts of mathematical creativity, task creation, and picture books, an integrated didactic framework is formed that enables the multidimensional development of students – cognitive, metacognitive, emotional, and social (Sheffield, 2013).

The picture book provides a motivational and contextual framework; task creation activates the procedural and reflective dimension of thinking; and creativity represents the ultimate outcome of this process. Within this approach, students move from receptive to productive learning: from observers and solvers to researchers and authors. They combine logical and aesthetic thinking, symbolic and linguistic structures, gradually freeing themselves from formulaic patterns. Sternberg (2003) refers to this process as classroom creativity – the ability of a student to reinterpret the familiar, combine ideas, and create new patterns of thinking within an educational context. This process aligns with the contemporary perspectives that view students not only as problem solvers but also as active creators and redesigners of mathematical ideas through problem posing and exploratory learning experiences (Cai & Hwang, 2021). Furthermore, creativity-oriented mathematical activities that include communication, visualization, open-ended exploration, and the generation of multiple solutions are considered particularly effective in supporting deeper mathematical understanding and flexible thinking (Bicer et al., 2021; Gridos et al., 2022). Such an integrated model is not only a tool for learning mathematics but also a means of developing students' mathematical identity. Children who create their own tasks within a story experience mathematics as a tool for expression, not merely a set of rules (Mann, 2006; Silver, 1997). Research additionally suggests that supportive questioning, discussion, and reflective dialogue play an important role in helping students interpret, explain, and justify their mathematical ideas within creative learning environments (Monteleone, 2022). In digitally enriched and interdisciplinary contexts, creativity may be further strengthened through exploratory STEM-oriented and technology-supported activities that encourage experimentation, critical thinking, and authentic engagement with mathematical ideas (Al-Barakat et al., 2025; Suherman et al., 2021). In this sense, the combination of picture books, task creation, and creativity contributes not only to the understanding of mathematics but also to the development of curiosity, self-confidence, and meaning in learning – forming the foundation.

Research Aim and Research Questions

The aim of this study was to explore how picture books and problem-posing activities can support the development of mathematical creativity in primary school students with above-average mathematical abilities.

The study sought to examine the progression from reproductive toward more flexible and original forms of mathematical thinking during a series of creative workshops. A particular attention was given to students' fluency, flexibility, and originality in task creation, as well as to their verbal explanations, reflections, and metacognitive awareness during the activities.

The following research questions guided the study:

1. How do primary school students with above-average mathematical abilities demonstrate mathematical creativity during picture book-based problem-posing activities?
2. In what ways do students progress from reproductive toward transformational and creative forms of mathematical task creation?
3. Which elements of students' mathematical thinking, communication, and reflection emerge during creative task-design activities inspired by a picture book?

Given the exploratory and qualitative nature of the study, the focus was not on measuring achievement, but on understanding the processes through which mathematical creativity develops in authentic and open-ended learning contexts.

2 Methodology

Participants

The study involved four primary school students who demonstrated above-average abilities in school mathematics. The sample included one second-grade student, one third-grade student, and two fourth-grade students. The students were recommended by their teachers as highly motivated and successful in solving mathematical tasks, as well as inclined to participate in additional activities. All students attended supplementary mathematics classes. Participation was voluntary, with parental consent.

Instrument

The primary stimulus for the activities was the picture book Counting Creatures by Julia Donaldson, illustrated by Sharon King-Chai (publisher: Profil knjiga, Zagreb). The book was purchased and presented to the students in physical form during the introductory session, so that they could experience both the visual and tactile aspects of the story. In addition to the picture book, materials specifically prepared for this study were used:

- Selected illustrations of animals (in colour, on separate cards);
- Worksheets for creating mathematical crosswords and puzzles;
- A notebook for observations and brief records of conversations with the students.

All tasks were developed in Word document and adjusted to students' age.

Research Procedure

The study was conducted over four consecutive weeks in May 2025. The first meeting was dedicated to introducing the students to the facilitators and to each other, relaxing through mathematical games, and presenting the plan for the upcoming activities. During the following three weeks, three workshops were conducted, each lasting 90 minutes. At the beginning of the first workshop, students were introduced to the objective of the activities and to the picture book Counting Creatures. The teacher read the book aloud, while the students simultaneously followed the text and illustrations, asked questions, and commented on the content. After the reading, a discussion followed about the animals appearing in the story and the possibilities of linking these motifs to numbers, shapes, and quantities. While examining the picture book, the students discussed the illustrations, colours, and arrangement of the animals, paying a particular attention to details that later influenced their choice of animals and mathematical relationships in their own tasks. The picture book then served as a starting point for three interconnected workshops:

1. Mathematical Crossword – the students created tasks using numbers and animal symbols;
2. Mathematical Grids – independently constructing tasks within a 4×4 grid;
3. Mathematical Puzzles – designing their own problem-based tasks and riddles.

During each workshop, the facilitator recorded the observations and brief statements from the students, which were later used as qualitative data for interpretation. The conversations were spontaneous, with questions focusing on students' thinking processes, choice of numbers, and motivation ("Why did you choose this particular animal?", "What does your task represent?", "Can it be solved in more than one way?").

Data Analysis

The analysis of the collected data was conducted qualitatively, with the aim of understanding the process of developing mathematical creativity in the students over the three workshops. The analysis included the students' work, the facilitator's notes and observations, and the students' statements, with all sources compared and interpreted to ensure credibility and gain deeper insight. The analysis process began with open coding – each idea, comment, or student action was assigned a descriptive code reflecting its meaning. These codes were then grouped into broader categories based on the model of creative development proposed by Silver (1997) and Leikin (2009). In this way, three levels of student creativity were identified: reproductive, in which students imitate familiar patterns; transformational, in which they adapt and modify them; and creative, in which they independently generate original tasks and demonstrate divergent thinking. In addition to these levels, the thematic domains that emerged spontaneously were highlighted – the students' attitudes toward the task, type of mathematical thinking, and linguistic and symbolic creativity. By triangulating different data sources – written work, verbal statements, and observations – the shift from dependence on the given patterns toward independent creation was tracked, with key indicators being the changes in students' language, motivation, and reflection. Rather than quantification, the interpretation was based on describing cognitive changes and the development of metacognitive awareness, with a particular value placed on the moments of spontaneous insight and self-correction. Student creativity was recognized through three criteria – fluency, flexibility, and originality – which were evaluated descriptively, not to assess performance but to understand the thinking process. All data were analysed anonymously, with parental informed consent, and the students' statements and work were used exclusively for research purposes, respecting ethical principles and protecting the participants' identities.

3 Results

First Workshop – Introduction to the Picture Book and Creating a Mathematical Crossword

Workshop Objectives:

- To stimulate interest in the picture book and the recognition of mathematical relationships within it;
- To develop the ability to classify and identify patterns;
- To encourage creative thinking through the creation of the students' own mathematical tasks.

Activity Procedure:

The workshop began with a joint review of the picture book Counting Creatures and a discussion about the animals appearing in it. The students talked about which animals they liked the most and how they could categorize them (e.g. those that fly, swim, or walk on land). Next, they were given an example of a mathematical crossword based on addition and subtraction. The task was to design their own version of the crossword incorporating all four arithmetic operations (Figure 1). After creating their crosswords, the students indicated the parts to be removed, and the teacher transformed their drafts into the final versions of the tasks in Word. Finally, the students solved a task using animal illustrations arranged in a 4×4 grid, where each animal represented an unknown value. They checked the correctness of the solutions and compared strategies. The activity concluded with a review of the album Animal Kingdom and the selection of four animals that would be used in the next workshop.

Observations:

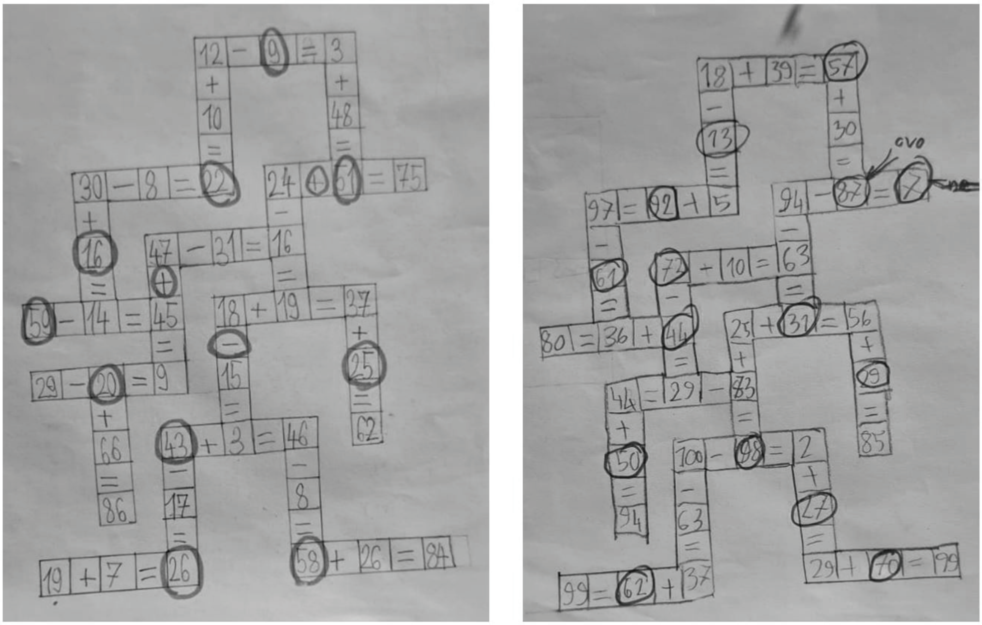
At the beginning, the students showed a strong need for rules – they constantly sought confirmation that they were "doing it correctly." Accustomed to closed-ended tasks typical of textbooks, where there is only one correct answer and the goal is to find the "right solution" rather than explore possibilities, they found it difficult to accept that they could design a task based on their own ideas, without a given structure. Their first attempts at creating crosswords were formulaic – the students almost literally copied the example provided, changing only a few numbers or symbols. It was only after the teacher repeatedly emphasized that "you can decide for yourselves what should be the unknown" and that "your task does not have to look like mine" that signs of imagination began to emerge: some students chose to include multiplication and division, while others combined different rows of animals. The students displayed a strong interest in the element of play and aesthetics – the drawing of animals and their arrangement in the grid helped them "step out" of mathematical formalism.

Interestingly, the younger students (2nd and 3rd grade) were more free in their experimentation, while the older ones demonstrated greater caution and analytical thinking, as if they were more aware of "mathematical accuracy." During the post-workshop discussion, they themselves remarked that it was "interesting because there is no correct answer," but also that it felt "strange because they weren't sure if it was right."

This duality (uncertainty and excitement) served as an important indicator of the initial shift toward creative thinking.

Figure 1

Examples of the students' crosswords



Second Workshop – Creating Own Tasks with an Animal Theme

Workshop Objectives:

- To develop the ability to translate real-life situations into a mathematical model;
- To encourage collaborative problem-solving and peer evaluation of tasks.

Activity Procedure:

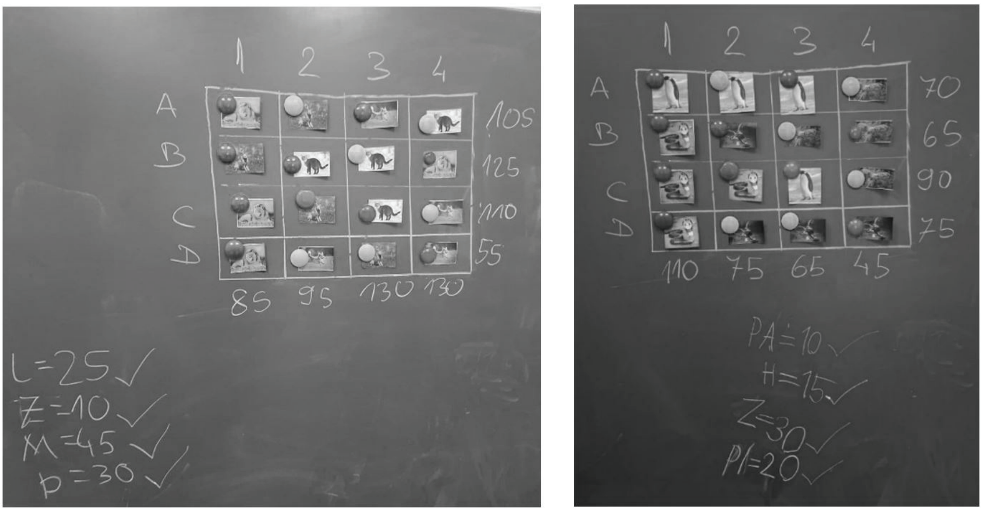
The workshop began with a review of the previous task and the distribution of the selected animal illustrations. A 4×4 grid was drawn on the board, and each student independently designed their own task using the same structure (Figure 2). After creating their tasks, the students presented them on the board, and everyone solved each other's tasks collaboratively. During the crossword creation, one student incorrectly assigned values to the animals, which served as an example for a joint discussion on the importance of establishing a clear connection between the symbols and numbers.

Observations:

In the second workshop, the students were already more comfortable in the creative role, but they still sought structure. The most common pattern was attempting to "make the same task as the teacher, but with different animals." This indicates that the process of moving away from formulaic approaches requires repeated practice and modelling. When they saw how their peers created different combinations, they began spontaneously discussing the possible variations: “What if the lion has a higher number than the elephant?” “Can two rows have the same total?” These discussions marked the moment when the students started thinking mathematically in an open way, exploring relationships among elements. Younger students still relied on visual support (illustrations, colours), while older students tried to mathematically “optimize” the task (e.g. ensuring all rows have the same sum). Such attempts showed that the students were intuitively introducing the concepts of symmetry and balance, even if they were not consciously aware of it. Comparing the first and second workshops, it is evident that a shift from imitation to creation occurred – the students moved from reproducing task forms to experimenting with their content.

Figure 2

Examples of the students' tasks



Third Workshop – Mathematical Puzzles

Workshop Objectives:

- □ To develop logical and problem-solving thinking;
- □ To encourage independent formulation of problem situations.

Activity Procedure:

At the beginning, the students were given four examples of mathematical puzzles (e.g. time, numerical, and geometric riddles):

- □ I am a clock. At what time do my hands overlap?
- □ If you add double my age to my age, you get 72. How old am I?
- □ The sum of my digits is 6. What number am I?

- I am a clock. When my hands form a perfect straight line, what time is it?
- If you multiply me by zero, the result is always the same. What number am I?
- In the meadow there are 4 ducks, 6 dogs, and 3 swans, observed by Iris and Emanuel. How many legs are in the meadow?
- I have a line segment, and a perfect arc connects its endpoints. What am I?
- If three hours ago it was 13:15, what time is it now? What time will it be in 75 minutes?

After solving the initial puzzles, the students were tasked with creating their own mathematical riddles. The examples of the students' puzzles include:

- A dolphin weighs 500 kg. A great white shark weighs 2 tons. The dolphin's weight fits 4 times into the shark's weight.
- There are two butterflies and four ladybugs on a flower. How many spots do they have together if each butterfly has 4 spots on its wings?
- An owl is 80 cm tall. A giraffe is 4 m tall. The owl's height fits 5 times into the giraffe's height.
- A royal cobra weighs 12 kg. A cat weighs 4 kg. The cat's weight fits 3 times into the royal cobra's weight.
- In a primary school, there are 8 grades, and each grade has classes a and b. If there are 448 students in total, how many students are in each class?
- On a table, there are 12 purple pencils, 20 green pencils, 7 orange pencils, and 15 yellow pencils. Which colour is most likely to be drawn, and which is least likely?

Observations:

In the third workshop, the differences in the students' levels of cognitive flexibility became most apparent. When first tasked with creating their own puzzles, some students said, "I don't know what I'm allowed to write" or "What if it's not correct?" Such statements reveal a deeply rooted fear of making mistakes, characteristic of students accustomed to closed-ended, single-answer tasks. However, after jointly solving several examples, the students began to relax. One fourth-grade student spontaneously created a puzzle about classes and the number of students – a task involving proportional reasoning and algebraic thinking. Other students followed this example, adding their own ideas and combining everyday objects (pencils, animals, clocks) with mathematical concepts. Creativity was expressed not only in content but also in linguistic formulation: the students used humour, storytelling, and rhyme (e.g. "I am a number that disappears when multiplied by zero!"). These examples demonstrate the development of divergent thinking – the ability to view a mathematical concept from multiple perspectives. Interestingly, the students themselves noticed that textbook tasks "cannot be changed," while their own tasks could: "I can change mine to make it harder!" This insight is crucial – it marks the shift from passive problem-solvers to active creators of knowledge.

Observation Synthesis

Throughout all three workshops, the conversations with the students served as informal interviews and moments of reflection. The students described how difficult it was for them to create a problem, explaining that they were "used to always knowing the solution" at school. When given the freedom, they experienced both excitement and discomfort: excitement because they could make their own decisions, and discomfort because they were unsure whether a "correct answer" existed. Their remarks reveal that the traditional school practice, dominated by closed, single-solution problems, tends to limit imagination and divergent thinking. However, after several attempts, the students began to display curiosity, humour, experimentation, and flexibility – features of creative mathematical thinking. Such students' comments and observations confirm that the workshops provided a safe space for mathematical play, an environment free from evaluation or fear of mistakes. Within this context, the students not only developed their interest, motivation, and understanding, but also achieved something deeper: creative autonomy in mathematical expression.

4 Discussion

General Impression and Initial Student Reactions

During the introductory session, the students were introduced to the picture book Counting Creatures (Donaldson & King-Chai, 2021), which served as the contextual framework for all subsequent activities. While reading and observing the illustrations together, they demonstrated a high level of interest, which is consistent with the previous findings that picture books act as strong motivational tools in mathematics learning (Marston, 2014; van den Heuvel-Panhuizen et al., 2016). The discussion about the animals depicted in the story proved particularly stimulating. The students expressed curiosity, asked questions about animals uncommon in their everyday environment, such as scorpions, spiders, and marine fish, and spontaneously compared their size, speed, and number of limbs. One student remarked: "A spider has more legs than a scorpion, but I think the scorpion attacks faster." Such comments illustrate how a spontaneous conversation about a picture book can evolve into mathematical thinking, involving classification, comparison, and quantification (Shatzer, 2008; Whitin & Whitin, 2004). Through this dialogue, the students began developing mathematical language and forming conceptual links between the real world and abstract mathematical ideas, reinforcing the importance of a narrative in early mathematical education (Leikin & Pitta-Pantazi, 2013). At the same time, the open and multimodal nature of the activities encouraged the students to generate diverse interpretations and ideas, which is considered an important foundation of mathematical creativity and flexible thinking (Bicer et al., 2021; Joklitschke et al., 2022).

The Process of Task Creation – From Template to Originality

The initial activities proved to be highly demanding for the students. Although they were motivated, they showed uncertainty at the moment when they were asked to design a mathematical task on their own. They frequently sought reassurance ("Is this okay?", "Can I do it like this?") and at first imitated tasks from their textbooks. This initial phase, characterized by the reproduction of familiar patterns, aligns with the findings of Cankoy (2014) and Kontorovich et al. (2012), which indicate that most students initially produce closed tasks with a single, clear solution. Similar findings were reported by Cai and Hwang (2021), who observed that students often begin the problem-posing process by reproducing textbook structures before gradually moving toward more flexible and original mathematical constructions. In the first workshop, almost all students formulated their tasks according to a familiar pattern: "The sum of the numbers is…", "Which number is missing?" The tasks were correct but lacked any creative deviation. During this phase, the reproductive type of thinking prevailed (Krutetskii, 1976; Leikin, 2009), and the students focused more on formal correctness than on meaning. As the workshops progressed, a gradual transformation in their thinking became noticeable. During the second workshop, the students began modifying the given conditions – they replaced numbers, added stories, and introduced elements of humour. For example, one student included "a lion that runs faster than a crocodile swims" in their task, thereby transforming a mathematical relationship into a narrative situation. Such a transformation indicates a transition to the transformational phase of creativity, in which students modify familiar structures and introduce their own ideas (Leikin, 2009; Silver & Cai, 2005). This shift toward modifying and restructuring familiar mathematical patterns corresponds to the findings on creativity-directed mathematical tasks, where open-ended and exploratory activities stimulate flexibility and originality in students' thinking (Bicer et al., 2021). In the final workshop (mathematical brain teasers), the students demonstrated a much higher level of independence and originality. The tasks were diverse, often based on play and logic rather than on arithmetic operations. One student created a task in which "fish swim in different directions, and you have to figure out which one is the fastest if each changes direction three times." Such tasks indicate the development of divergent thinking and the ability to create open-ended situations (Runco & Acar, 2012). The emergence of multiple possible interpretations and solution paths is also consistent with research emphasizing the importance of flexibility, fluency, and originality as central dimensions of mathematical creativity (Gridos et al., 2022). At this stage, the students began to free themselves from patterned templates, which was also reflected in their own statements: "Now I can come up with it myself; I don't have to look at how it's written in the book." "It's more interesting when I choose what will be in the task." These comments demonstrate the emergence of a sense of ownership over learning and a shift from external control to intrinsic motivation (Beghetto & Kaufman, 2014; Mann, 2006). Such findings support the view that problem posing enables students to move from passive reproduction toward active mathematical authorship and creative engagement (Cai & Hwang, 2021).

Development of Mathematical and Metacognitive Thinking

The analysis of the students' statements and work revealed that, throughout the process of task creation, metacognitive awareness gradually developed. The students began to reflect on their own thinking, questioning whether a task was "difficult enough" or "had more than one solution." One student remarked: "I first made this task wrong, because it couldn't be solved, so I added another number." Such statements indicate self-correction and reflection on one's thought process, which, according to Lithner

(2008) and Leikin (2009), are the key indicators of a shift from imitative to creative reasoning. The students' increasing awareness of the quality, structure, and solvability of their own tasks also reflects elements of rigorous mathematical thinking, particularly the connection between conceptual understanding, reasoning, and reflective problem construction (Firmasari et al., 2022). As the study progressed, the students demonstrated an increasing ability to assess the meaningfulness and logical coherence of a task. In addition, the moments in which the students discussed whether a task could have "more than one solution" indicate the emergence of flexible mathematical reasoning and divergent thinking, both recognized as important aspects of mathematical creativity (Gridos et al., 2022; Joklitschke et al., 2022). Particularly noteworthy is that they often expressed emotional engagement during discussions. On several occasions, they commented that it was "more fun than at school" or that they "would like to do math like this more often." These elements of emotional involvement confirm what Marston (2014) and Shatzer (2008) observed – that the integration of picture books and task creation can foster a positive attitude toward mathematics and reduce anxiety. The role of dialogue and reflective questioning during the workshops also appears important, as supportive questioning strategies are known to encourage students to explain, justify, and reinterpret their mathematical thinking in creative ways (Monteleone, 2022).

Key Patterns and Phases of Creativity Development

Based on the data analysis, three dominant phases of student creativity development can be identified (Table 1):

Table 1

Three Phases of Creativity Development

Phase	*Description*	*Indicators*
Reproductive	Students imitate familiar tasks and seek confirmation.	Repetition of textbook patterns, uncertainty, focus on correctness
Transformational	Students begin modifying existing tasks and introducing their own ideas.	Inclusion of humour, stories, symbolic representations; combining animals and numbers
Creative	Students create original tasks with multiple solutions and reflect on their own thinking process.	Divergent thinking, independence, verbalization of thought processes.

These three phases fully align with the models of creative development proposed by Silver (1997), Leikin (2009), and Sriraman (2009). In the context of working with gifted students, this development demonstrates that creativity does not emerge spontaneously; rather, it requires time, experience, and a supportive environment in which exploration and making mistakes are permitted.

Connection with the Theoretical Framework

The research results confirm the theoretical assumptions regarding the importance of open-ended tasks and problem posing as tools for developing mathematical creativity (Cai & Hwang, 2019; Leikin, 2009). Through the process of creating their own tasks, the students progressed from the level of reproduction to the level of generating new mathematical structures, demonstrating the development of flexibility and fluency in thinking (Runco & Acar, 2012).

This progression is consistent with more recent findings suggesting that students gradually move from imitating textbook structures toward independently redesigning and constructing mathematical ideas through problem posing (Cai & Hwang, 2021). This shift corresponds to the model of "generative thinking," which involves taking an active role in the construction of knowledge (Beghetto & Kaufman, 2014; Mann, 2006). At the same time, the picture book played a key motivational and symbolic role, as it allowed mathematics to be experienced within a narrative and aesthetic context (Shatzer, 2008; Whitin & Whitin, 2004).

The multimodal and open-ended character of the picture book activities also aligns with research emphasizing that creativity-oriented mathematical tasks should encourage visualization, communication, exploration, and multiple interpretations of mathematical ideas (Bicer et al., 2021; Joklitschke et al., 2022). The combination of the picture book and problem-posing activities proved particularly effective for gifted students, as it fostered their curiosity, sense of autonomy, and intrinsic motivation.

This research situation supports Stern's (2003) claim that "classroom creativity" develops precisely in contexts where students have the freedom to reinterpret the familiar and create something new. As Jeffrey and Craft (2004) emphasize, creative learning emerges when students can make their own decisions, explore, and connect knowledge from different domains. Similarly, studies on mathematical creativity indicate that students' originality and flexibility increase when they are encouraged to generate multiple solutions and reinterpret mathematical relationships in novel ways (Gridos et al., 2022). In this sense, correlating mathematics with other subjects, particularly with nature and the animal world, holds exceptional potential. A natural context allows students to recognize abstract mathematical relationships (such as number, proportion, or symmetry) in the real world and to connect them with personal experience (Naylor & Keogh, 2013).

Linking mathematical content with picture books that depict nature and animals further stimulates emotional engagement, as students develop a sense of closeness and identification with the situations in the story (Bintz & Moore, 2002). Such integration of artistic and natural science content fosters curiosity, empathy, and divergent thinking (Egan, 2005; Fleer, 2010). Interdisciplinary and STEM-oriented approaches are also recognized as important environments for the development of creative mathematical thinking, because they connect mathematics with authentic, meaningful, and exploratory experiences (Suherman et al., 2021). In this sense, the picture book becomes a bridge between children's imagination and reality, and mathematics becomes a tool for understanding the world around them.

Research suggests that the correlation between mathematics and natural sciences increases students' motivation and conceptual understanding because it enables experiential learning (Drake & Burns, 2004). Students more easily grasp abstract concepts when they can connect them to concrete examples from nature – through counting, comparing sizes, and observing patterns and rhythms in the animal world. Furthermore, a supportive dialogue and reflective questioning during these activities may additionally strengthen students' metacognitive awareness and their ability to explain and justify mathematical ideas (Monteleone, 2022).

It can therefore be concluded that integrating picture books, nature, and mathematical problem posing contributes not only to the development of cognitive abilities but also to the formation of the emotional and aesthetic dimensions of mathematical thinking. This approach strengthens students' motivation, fosters a sense of meaningfulness, and promotes the development of a deeper relationship with mathematics and the world around them. The findings also support broader perspectives on mathematical creativity that view creativity not as an isolated cognitive trait, but as a multidimensional process shaped by context, interaction, communication, and opportunities for open-ended exploration (Joklitschke et al., 2022).

5 Conclusion

The students gradually moved, over the course of three workshops, from uncertainty and reproduction toward independent and creative thinking. By the end of the process, they had developed not only the ability to create mathematical tasks but also a positive emotional attitude toward mathematics and a sense of pride in their own contribution. The results confirm the importance of an integrated approach that combines a picture book, task creation, and creative thinking, showing that even at an early age, students can develop elements of mathematical creativity if they are given enough freedom, support, and encouragement.

Mathematical creativity does not develop spontaneously, but rather as a result of carefully designed and methodically guided activities that provide students with freedom of thought and expression. The picture book, serving as a starting point that connects story, image, and number, proved to be an ideal medium for fostering children's creative thinking. Through the process of creating tasks, the students experienced mathematics not as a static system of rules, but as a space for exploration, play, and imagination. Such an approach transforms not only the way students solve mathematical problems but also the way they perceive themselves as mathematical thinkers. It is precisely in this transformation – from a student who reproduces to a student who creates – that the most important contribution of this study lies, as well as a guideline for future practice: in every child, regardless of age, the seed of mathematical creativity can be sown if they are given the opportunity to experience mathematics as a story they, too, can tell.

Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, the study involved a very small sample of participants, consisting of only four primary school students, which limits the possibility of generalizing the results to a broader population. In addition, all participants were identified by their teachers as students with above-average mathematical abilities and were already involved in supplementary mathematics activities. Therefore, the findings primarily reflect the experiences and creative processes of mathematically motivated and high-achieving students, and may differ from those of students with average or lower mathematical achievement.

Another limitation relates to the qualitative and exploratory nature of the study. The interpretation of students' creativity was based on observations, students' work, and verbal statements, which inevitably involves a degree of subjective interpretation. Furthermore, the workshops were conducted over a relatively short period of time, making it difficult to examine the long-term development and sustainability of mathematical creativity and metacognitive awareness. The study was also limited to one specific picture book and a particular set of creative activities, which means that different literary stimuli, classroom contexts, or instructional approaches might lead to different outcomes. Despite these limitations, the study provides valuable insights into the potential of picture books and problem-posing activities as tools for fostering mathematical creativity in young learners.

Suggestions for Future Research

Future research could focus on the long-term development of mathematical creativity and on observing changes in students' thinking over an extended period. It would be interesting to explore how continuous engagement in task creation throughout the school year influences students' metacognitive regulation and creative thinking style. It would also be useful to conduct comparative studies between students who learn mathematics in a traditional way and those who participate in programs that include picture books, narrative, and task creation. Such a design could show the extent to which creatively structured activities affect achievement, motivation, and the emotional relationship toward mathematics.

Further research could also include teachers, examining their attitudes toward task creation and the role of creativity in mathematics teaching. It would be particularly beneficial to develop methodological manuals and program modules that would help teachers systematically and purposefully introduce task creation activities into regular lessons. In addition, interdisciplinary approaches, such as connecting mathematics and literature, offer great potential for investigating the impact on the development of mathematical language, imagination, and conceptual understanding. Finally, it is worth exploring digital tools that could support this type of activity – for example, the use of GeoGebra, digital picture books, or platforms for collaborative task creation. Such research could contribute to the development of contemporary teaching models that combine technology, narrative, and creativity with the aim of achieving deeper and more meaningful learning of mathematics.

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Slikanica kot spodbuda za matematično ustvarjalnost v osnovnošolskem izobraževanju

Cilj kvalitativne raziskave je bil preučiti, kako je mogoče spodbujati matematično ustvarjalnost z integriranim pristopom, ki povezuje slikanico, pripoved in ustvarjanje matematičnih nalog (problem posing). Raziskava je bila izvedena z nadarjenimi učenci nižjih razredov osnovne šole. Želeli smo ugotoviti, kako lahko interdisciplinarni kontekst prispeva k razvoju ustvarjalnega mišljenja, fleksibilnosti, izvirnosti in metakognitivne zavesti pri otrocih, ki že kažejo visoke matematične sposobnosti. Izhodiščna predpostavka je bila, da lahko slikanica kot medij, ki povezuje zgodbo, podobo in število, služi kot močan spodbujevalnik matematične ustvarjalnosti, če se uporablja v didaktično premišljenem in metodično vodenem procesu.

Ustvarjalnost v matematiki je opredeljena kot sposobnost ustvarjanja novih in dragocenih idej znotraj matematičnega konteksta (Leikin, 2009; Silver, 1997). Sodobne raziskave (Runco & Acar, 2012; Sriraman, 2005) izpostavljajo tri osnovne dimenzije matematične ustvarjalnosti: fluentnost (številčnost idej), fleksibilnost (različni pristopi k reševanju) in izvirnost (novost in nenavadnost ideje). Takšna ustvarjalnost ne pomeni le odkrivanja novih teoremov, temveč tudi sposobnost učencev, da postavljajo vprašanja, opažajo povezave med izrazi in oblikujejo lastne naloge.

Sriraman (2005) razlikuje dve ravni matematične ustvarjalnosti: profesionalno, značilno za znanstvenike, in učilniško, ki se kaže v učenčevi sposobnosti reinterpretacije znanega in ustvarjanja novih pomenov v okviru pouka. Ta druga raven, tako imenovana učilniška ustvarjalnost, je glavni predmet te raziskave. Po Sternbergu (2003) ustvarjalnost v učilnici nastaja takrat, ko imajo učenci možnost samostojnega raziskovanja, odločanja in prevzemanja tveganja za napake, pri čemer učitelj deluje kot spodbujevalec in ne kot nosilec pravilnih odgovorov.

Eden najučinkovitejših načinov za spodbujanje matematične ustvarjalnosti je ustvarjanje nalog (problem posing) – proces, v katerem učenci sami oblikujejo, preoblikujejo ali rekonstruirajo matematične probleme (Silver & Cai, 2005). Tak pristop spodbuja aktivno konstruiranje znanja, saj morajo učenci razumeti odnose med količinami in operacijami, da bi oblikovali smiselno nalogo. Cai in Hwang (2019) izpostavljata tri razvojne faze te veščine: reprodukcijo znanih vzorcev, modifikacijo in kreacijo. Ravno skozi ta proces učenci prehajajo od posnemanja k ustvarjanju, kar predstavlja bistvo ustvarjalnega učenja matematike.

Vloga slikanice v tej raziskavi izhaja iz interdisciplinarnega pristopa, ki povezuje jezik, umetnost in matematiko. Po Shatzer (2008) ter van den Heuvel-Panhuizen in sodelavcih (2016) so slikanice močan spodbujevalec za razvoj predmatematičnih pojmov, saj hkrati aktivirajo vizualne, jezikovne in simbolne modalnosti. Ko učenci analizirajo ilustracije, primerjajo velikosti in količine ter povezujejo zgodbo s številkami, spontano razvijajo logično razmišljanje in intuitivno geometrijo. Slikanica *tako postane most med čustvenim in kognitivnim vidikom učenja – povezuje zgodbo z matematiko na način, ki učencu daje občutek smisla in osebne vključenosti.*

S kombinacijo slikanice, ustvarjanja nalog in ustvarjalnosti je bil oblikovan integrirani didaktični okvir, ki omogoča večdimenzionalni razvoj učenca – kognitivni, metakognitivni, čustveni in socialni. Tak pristop vodi učenca od receptivnega k produktivnemu učenju – od pasivnega prejemnika informacij k ustvarjalcu znanja.

V raziskavi so sodelovali štirje učenci nižjih razredov osnovne šole (drugi, tretji in četrti razred), ki so jih učiteljice prepoznale kot izrazito motivirane in uspešne pri matematiki. Vsi učenci so obiskovali dodatni pouk matematike in kazali zanimanje za zahtevnejše naloge. Udeležba je bila prostovoljna in s soglasjem staršev.

Kot glavni spodbujevalec je bila uporabljena slikanica Brojalica (Donaldson & King-Chai, 2021). Raziskava je potekala štiri tedne in je obsegala tri delavnice po 90 minut, ki so imele različne teme:

1. *matematična križanka: izdelovanje nalog s številkami in živalmi iz slikanice;*
2. *matematične tabele: ustvarjanje nalog v mreži 4×4 in skupno reševanje;*
3. *matematične uganke: oblikovanje lastnih problemskih in logičnih nalog.*

V vsaki delavnici je raziskovalka beležila opažanja, izjave in komentarje učencev, ki so bili pozneje kvalitativno analizirani. Analiza je vključevala odprto kodiranje (Miles & Huberman, 1994), združevanje kod v kategorije ter njihovo interpretacijo po modelih ustvarjalnega razvoja, ki sta jih predlagala Silver (1997) in Leikin (2009). Triangulacijo virov – napisanih izdelkov, opažanj in izjav – je omogočila sledenje premiku učencev od posnemanja k ustvarjanju. V prvi delavnici so učenci kazali izrazito potrebo po pravilih in varnosti. Njihovi prvi poskusi so bili skoraj dobesedne kopije znanih nalog, kar potrjuje, da šolska praksa pogosto omejuje ustvarjalnost. Ko jim je učiteljica dovolila, da sami odločijo, kako bo naloga videti, so se pojavili prvi znaki domišljije: spreminjali so številke, dodajali lastne ideje in vključili element igre.

V drugi delavnici je bil opazen napredek: učenci so začeli primerjati naloge, razpravljati o možnih rešitvah in presojati smiselnost svojih odločitev. Pri mlajših učencih je prevladoval vizualni vidik (barve, razporeditev), starejši pa so intuitivno uvajali matematične pojme, kot sta simetrija in enaki vsoti. Tretja delavnica, posvečena ugankam, je prinesla največ izvirnosti in divergentnega razmišljanja. Učenci so oblikovali naloge, ki so združevale vsakdanje situacije (živali, predmeti, čas) z abstraktnimi pojmi, kot so razmerje, verjetnost in sorazmernost. V nekaterih nalogah so uporabili pripovedne elemente, humor in ritem, kar kaže na preplet jezikovne in matematične ustvarjalnosti. Učenci so poudarili, da jim je dejavnost »zanimiva, ker lahko sami izbirajo« ter da bi »želeli, da bi delo pri pouku matematike pogosto potekalo na tak način«. Njihove izjave kažejo na razvoj pozitivnega čustvenega odnosa do matematike in občutek, da lahko upravljajo in oblikujejo svoje učenje.

Analiza podatkov je pokazala tri razvojne faze:

1. *reproduktivna faza – posnemanje znanih vzorcev in iskanje potrditev, ali so pravilni;*
2. *transformacijska faza – spreminjanje znanih nalog in vključevanje lastnih idej;*
3. *ustvarjalna faza – samostojno ustvarjanje izvirnih nalog in refleksija mišljenja.*

Te tri faze v celoti ustrezajo modelom ustvarjalnega razvoja po Silverju (1997) in Leikinu (2009), vendar so bile v raziskavi jasno zaznane tudi na ravni čustvenega doživetja – učenci so od negotovosti in zadržanosti postopoma prehajali k samozavesti in navdušenju.

Metakognitivna zavest učencev se je opazno razvijala skozi vsako delavnico. Učenci so začeli presojati svoje odločitve (»Ta naloga nima rešitve, dodal sem še eno številko.«), kar kaže na refleksijo in samokorekcijo. Take situacije kažejo na prehod od imitativnega k ustvarjalnemu sklepanju (Lithner, 2008). Pomembno vlogo je imel tudi čustveni vidik. Učenci so večkrat poudarili, da lažje razmišljajo, ko lahko izbirajo; zdelo se jim je bolj zabavno, kadar ni bilo enega pravilnega odgovora. Občutek svobode je zmanjšal strah do napak in povečal notranjo motivacijo, kar je v skladu z Marston (2014) in Whitin & Whitin (2004).

Rezultati potrjujejo pomen odprtih nalog in t. i. pristopa problem posing pri razvoju matematične ustvarjalnosti (Cai & Hwang, 2019; Leikin & Pitta-Pantazi, 2013). Kombinacija slikanice in ustvarjanja nalog je učencem omogočila povezovanje logičnega, estetskega in simbolnega razmišljanja ter postopno prevzemanje aktivne vloge v učenju.

Tak model dela kaže na to, da tudi nadarjeni učenci, kljub večjim sposobnostim, potrebujejo spodbudno in sproščeno učno okolje, da bi lahko razvijali ustvarjalno samozavest. Dejavnosti, v katerih spodbujamo domišljijo in osebni izraz, ne razvijajo samo ustvarjalnega mišljenja, ampak tudi spreminjajo doživljanje matematike: iz rigidne in abstraktne discipline preide na področje osebnega izraza in raziskovanja. V širšem smislu pa rezultati potrjujejo, da se matematična ustvarjalnost ne pojavi spontano, ampak je rezultat sistematičnega in metodično vodenega dela, v katerem imajo učenci možnost izbire, napake in različne interpretacije pa so dobrodošle. Slikanica je v tem procesu služila kot most med pripovedjo, zgodbo in matematiko, saj je omogočila čustveno navezanost in motivacijo, kar je še posebej pomembno pri mlajših otrocih.

Skozi tri delavnice so učenci prehodili pot od negotovosti in reprodukcije k neodvisnemu, refleksivnemu in ustvarjalnemu razmišljanju. Razvili so sposobnost oblikovanja lastnih nalog, izražanja svojih idej in prepoznavanja matematičnih odnosov v slikanici, hkrati pa so oblikovali pozitiven čustveni odnos do matematike in občutili ponos zaradi svojega doprinosa k učenju.

Najpomembnejši doprinos raziskave je potrditev, da se matematična ustvarjalnost lahko razvija že v zgodnji mladosti, če učencem zagotovimo dovolj svobode in podpore. Slikanica se je pokazala kot učinkovit medij, ki povezuje čustva, zgodbo in števila, matematika pa ni le iskanje pravilnih odgovorov, ampak tudi prostor za igro in raziskovanje. Tak pristop spreminja tudi način, kako učenci vidijo sebe – od tistih, ki samo rešujejo naloge, do tistih, ki jih ustvarjajo.

Raziskava potrjuje, da so matematična ustvarjalnost, ustvarjanje nalog in slikanica medsebojno povezani koncepti, ki skupaj tvorijo močan okvir za razvoj učenca kot misleca, raziskovalca in ustvarjalca znanja. Matematična ustvarjalnost ni privilegij nadarjenih, ampak je ta moč prisotna v vsakem otroku; potrebno jo je samo prepoznati, spodbujati in negovati z dejavnostmi, ki povezujejo znanje, čustva in domišljijo.

Data Availability Statement

The article is based on research data deposited in Faculty of Humanities and Social Sciences and are not publicly available; however, they may be obtained from the author upon reasonable request.

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