Exploring Students' Creative Thinking through Collaborative Problem-Posing Activities

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ABSTRACT

Introduction. One of the most essential skills for students to cultivate in the 21st century is creative thinking. In the context of education, particularly in mathematics, the development of creative thinking is indispensable for fostering innovation and problem-solving. However, traditional teaching approaches often fall short in promoting creativity. Collaborative problem-posing has emerged as a promising strategy to address this gap. Yet, existing research provides limited insight into its practical implementation, particularly at the elementary school level. Moreover, previous studies have indicated significant variations in the levels of creative thinking among participants within collaborative groups.

Research methods. This study adopts an exploratory qualitative case study approach to examine the creative thinking capacities of elementary school students while collaborating in mathematical problem-posing. The study involved twenty fifth-grade students, categorized based on their level of mathematical competence (high, medium, and low). Data were collected through post-task problem-solving activities, focus group discussions (FGD), and individual interviews. The tasks required students to develop new problems based on open-ended mathematical scenarios. The data were analyzed using thematic coding, including data reduction, comparison, data building, and conclusion drawing, to provide a more holistic picture of the students' creative thinking processes and collaborative efforts.

Results. The analysis revealed that students with varying abilities were able to solve several tasks, which included problem-solving and posing related questions at more complex levels. Most groups tended to answer and pose questions based on sources they researched, aligning content and themes with previously addressed problems. Students worked collaboratively, demonstrating responsibility for tasks assigned by their peers. Although the level of collaboration varied among the heterogeneous groups, those exhibiting the highest levels of collaboration also demonstrated stronger creative thinking abilities.

Conclusion. The students were found to be highly creative in developing new problems and building miniature cities. Their success was largely attributed to their excellent communication and social skills, as well as positive group dynamics, which facilitated problem-posing activities. However, more emphasis could be placed on enhancing originality and novelty to further increase creativity in higher-level students.

KEYWORDS

creative thinking, collaborative problem-posing, elementary mathematics education, group dynamics, social skills, mathematical competence, innovation in education, student collaboration

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INTRODUCTION

Creative thinking has been widely recognized as a crucial skill for students to navigate an increasingly complex and dynamic world. International organizations such as UNESCO, the Council of Europe, and the International Association of Universities (IAU) emphasize the need to cultivate creativity as part of 21st-century education. UNESCO, through its Futures of Education initiative, highlights the importance of fostering students' ability to think critically, solve problems, and generate innovative ideas [1]. Similarly, the Council of Europe promotes competency-based learning, encouraging educational systems to move beyond memorization toward active knowledge construction and creativity. In line with these global educational priorities, research in mathematics education has increasingly explored strategies to enhance students' creative thinking [2].

Creative thinking is a critical skill that students should develop from an early age to enhance their conceptual understanding [3].These skills are fundamental to human progress, particularly in navigating rapid social and technological changes [4]. Integrating creative thinking into early educational experiences provides children with a robust foundation to shape the world they envision [5].However, in many educational settings, creative thinking skills often receive insufficient attention, limiting students' potential and hindering their journey toward self-actualization [6].

As one of the 6C competencies alongside connectivity, culture, critical thinking, communication, and collaboration [7], creative thinking is increasingly prioritized in Indonesia's education system. Educators must understand how to stimulate these skills for optimal development [8]. However, Indonesian students' creative thinking skills remain a concern. A 2015 TIMSS study ranked Indonesia 44th out of 49 countries in international mathematics scores, with an average reasoning score of 397, well below the international average of 500. Similarly, the 2022 PISA results showed a decline in Indonesia's mathematical proficiency score to 366, and the 2015 Global Creative Thinking Index ranked Indonesia 115th out of 139 countries [9]. These findings highlight the need for targeted strategies to enhance students' creative abilities [10; 11].

One effective approach to fostering creative thinking is problem-posing activities. Problem-posing involves generating new problems or reformulating existing ones [12] and is increasingly recognized as a key strategy for enhancing mathematical proficiency. Studies suggest it integrates evaluative stages of problem-solving [13; 14] Furthermore, mathematical problem-posing requires educators to consider students' needs and curriculum requirements. Research shows that teachers who engage in problem-posing enhance both student creativity and their own pedagogical knowledge [15; 16]. It encourages students to construct personal interpretations of real-world situations and express them as meaningful mathematical problems [17].

In the context of contemporary learning environments, it is essential to foster collaboration to enhance student understanding and optimize interaction among students during learning activities [18] and collaborative problem-posing has gained traction [19; 20]. However, interpretations of this approach vary. Schindler and Bakker examined it through a case study involving high school students [21], while Sung et al. outlined three main stages: (1) providing clues related to learning objectives, (2) using structured question templates, and (3) exposing students to expert questions for reflection [21].

A collaborative mobile learning system based on problem-posing has also been developed, consisting of "identification of key elements" and "problem-posing guidance." Students work in groups to identify learning objectives, confirm their location via QR codes, and receive relevant assignments. They then answer guiding questions, and correct responses activate support mechanisms for further question formulation. Wang and Hwang outlined the steps for posing collaborative problems, where students first solve an initial problem, formulate new problems, and discuss them with peers under teacher guidance [22]. Given the challenges in fostering creative thinking among Indonesian students, collaborative problem-posing emerges as a promising solution. By incorporating real-world contexts and encouraging collaboration, educators can create meaningful learning experiences that enhance students' creative thinking skills.

MATERIALS AND METHODS

This study employs an exploratory qualitative approach with a case study design to describe elementary school students' creative thinking abilities in collaborative problem-posing activities. A case study was chosen as it allows for natural and in-depth data collection through observation and interviews [23].The Focus Group Discussion (FGD) technique was used since problem-posing activities were conducted in groups [24].The study involved 20 fifth-grade students, grouped into teams of three based on their mathematics proficiency test results. The test revealed that 15% of students were in the high-ability category, 45% in the medium-ability category, and 40% in the low-ability category.

The research instrument consisted of worksheets with open-ended, non-routine mathematical problems on solid figures, allowing students to collaboratively pose new problems. The instrument was validated by a mathematics education expert who reviewed its content, construct validity, and clarity. Adjustments were made by eliminating redundant information and adding illustrative images. Data were gathered through post-solution problem-posing tasks, where students modified the conditions of solved problems to create new ones [25]. Student activities were recorded and observed, and their work was analyzed using a Creative Problem-Posing (CPP) skills matrix [26]. Analysis followed the constant comparison method, including data reduction, presentation, and conclusion drawing. To ensure reliability, students' written work was triangulated with interview transcripts and observation notes, focusing on problem-posing strategies, prior knowledge application, and factors influencing creativity.

Indicators of creative thinking and the collaboration rubric were based on students' ability to: Synthesize and generate ideas, apply ideas to construct problems, collaborate effectively in groups. Share responsibility for tasks, Make collective decisions, and Work interdependently to produce mutually successful outcomes.

Table 1

Collaboration rubric [27; 28]

Level	Criteria
Level 1	Students are not obligated to collaborate in pairs or groups.
Level 2	Students do collaborate within a group, but they do not share responsibility.
Level 3	Students do share responsibility, but they are not required to make important decisions together.
Level 4	Students do share responsibility and make important decisions together regarding the content, process, or outcome of their work, but their tasks are not interdependent.
Level 5	Students have shared responsibility, collaborate on substantial decisions regarding the content, process, or product of their work, and their tasks are interdependent. her responsibilities.

LITERATURE REVIEW

a. Creative Thinking

Creative thinking is an original and reflective process involving logic, intuition, and divergent thinking to generate novel ideas [29; 30]. It emphasizes fluency, flexibility, and novelty in constructing and evaluating ideas [31; 32]. In this study, creative thinking follows Silver's framework, categorizing students into five levels. *Very Creative* students (Level 4) demonstrate fluency, flexibility, and novelty, while *Creative* students (Level 3) exhibit fluency with either flexibility or novelty. *Quite Creative* students (Level 2) show only flexibility or novelty, *Less Creative* students (Level 1) display fluency alone, and *Not-Creative* students (Level 0) lack all three aspects [33].

b. Mathematical Problem Posing

Problem posing is a crucial mathematical activity recognized by mathematicians and educators [34]. It involves generating new problems and reformulating existing ones before, during, or after problem-solving [25]. The process follows systematic steps: preparation (setting goals and gathering context), problem generation, and revision. If a problem does not align with objectives, students are encouraged to refine it before final submission [35].

c. Collaborative Problem Posing

The 21st century requires learners to develop competencies in collaboration and creative thinking. Collaborative problem-solving integrates these skills, combining social and cognitive abilities [7]. Problem-posing, a key intellectual activity in scientific inquiry, enhances students' higher-order thinking [36]. Traditionally, it has been an individual task [37], but modern education emphasizes collaboration to deepen understanding [18] As a result, problem-posing is increasingly implemented collaboratively [19] Collaborative problem-posing differs from individual approaches by requiring communication, idea exchange, and joint decision-making. Students must discuss contexts, establish relationships between problem components, and negotiate solutions. This process fosters deeper engagement, shared reasoning, and the integration of diverse strategies to develop meaningful problems.

d. Relationship between Creative Thinking Ability, Problem Posing, and Collaborative

Silver provides indicators to assess learners' creative thinking skills—namely, fluency, flexibility, and novelty—through problem posing [38]. The relationship between these indicators can be illustrated in the following table.

Table 3

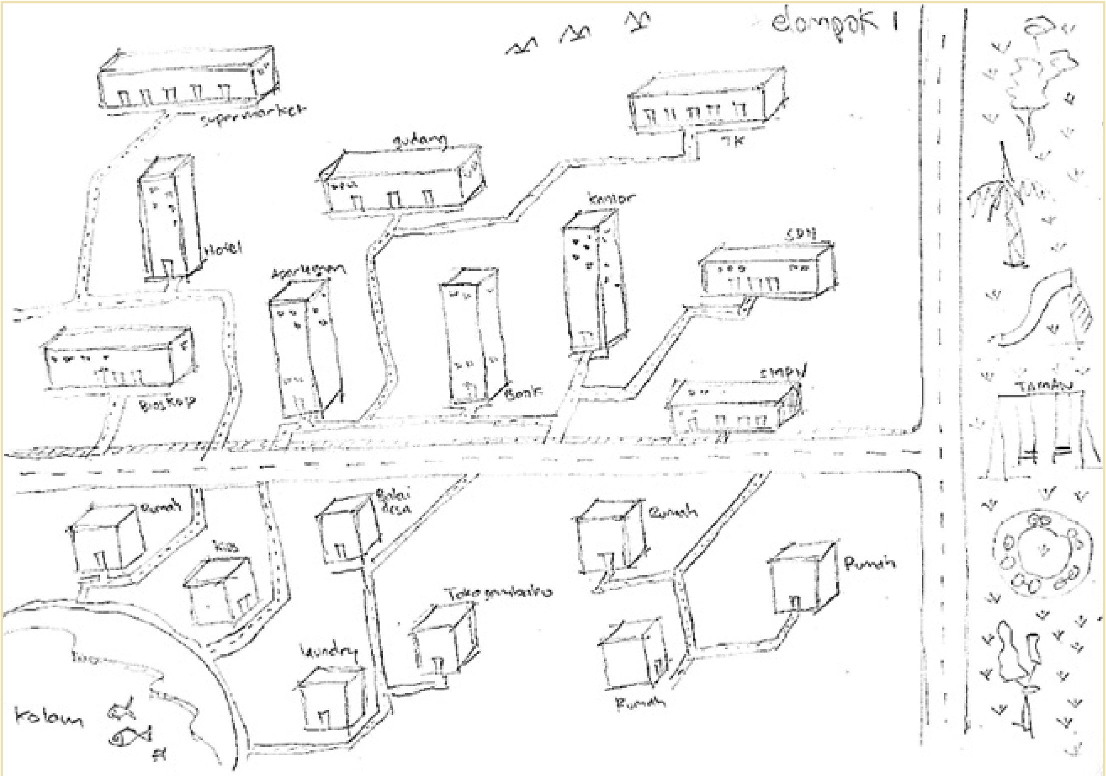
Relationship between Creative Thinking Ability, Problem Posing, and Collaborative

Indicators of Creative Thinking Ability	Collaborative Components	Collaborative Problem Posing
Fluency	Build and maintain a common understanding.	Students collaboratively build and sustain a shared understanding to generate multiple problems or pose issues that can be collectively solved within the group.
	Take appropriate action to pose a problem	Students take appropriate action together to create multiple problems or pose problems (issues) that can be solved together with group members
	Establish and maintain group organization.	Students form and maintain group organizations to create problems or pose problems (issues) that can be solved with group members.
Flexibility	Build and maintain a common understanding.	Students build and maintain shared understanding by posing problems that have different ways of solving with group members.
	Take appropriate action to pose a problem	Students take deliberate actions to collaboratively pose problems that can be solved through multiple approaches with their group members.
	Establish and maintain group organization.	Students establish and maintain group organization by collaboratively posing problems that can be solved through multiple approaches with their group members.
Novelty	Build and maintain a common understanding.	Students build and maintain shared understanding by analyzing several posed problems and then creating a distinct one. problem together with their group members.
	Take appropriate action to pose a problem	Students take appropriate action by reviewing several proposed problems and collaboratively creating a different problem with their group members
	Establish and maintain group organization.	Students establish and sustain group organization by reviewing previously posed problems and collaboratively creating a new and different problem with their group members.

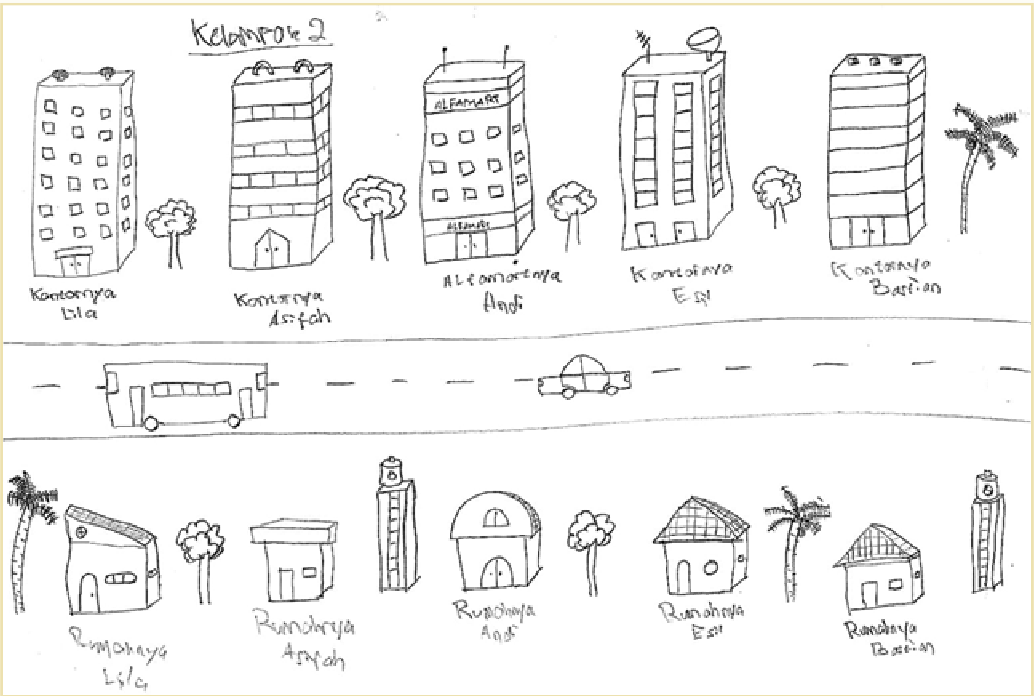
RESEARCH RESULTS

1. Problem-Solving Section

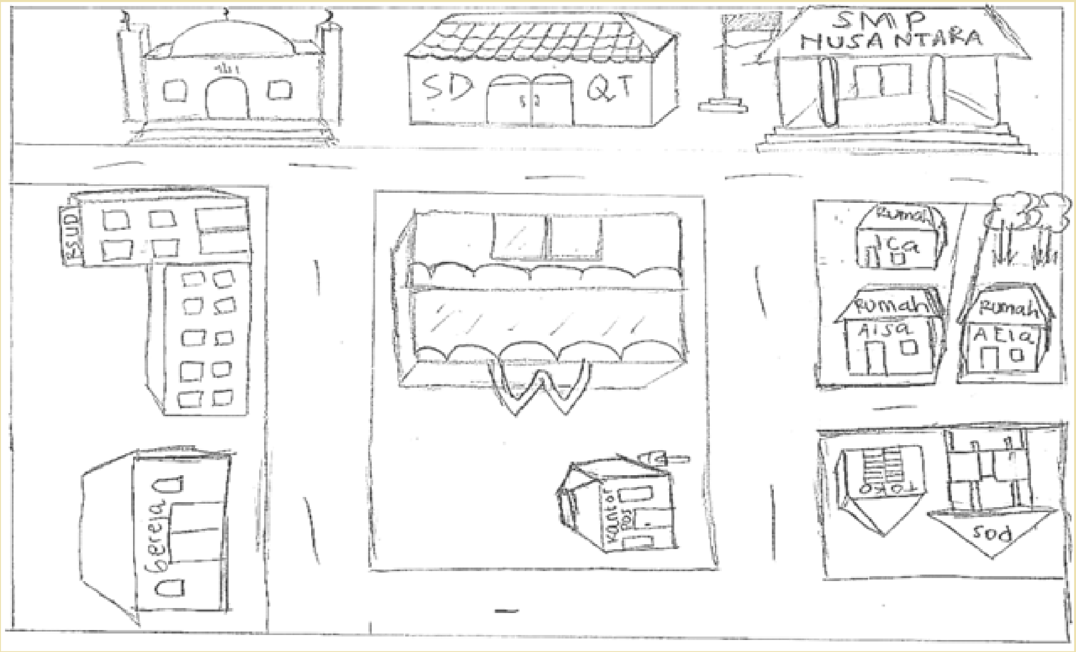
After obtaining the results of the mathematics proficiency test, we distributed the problem-posing test the following day. The test consisted of two activities: a problem-solving activity and a problem-posing activity focused on building spaces. The results of all the groups' responses are presented below:



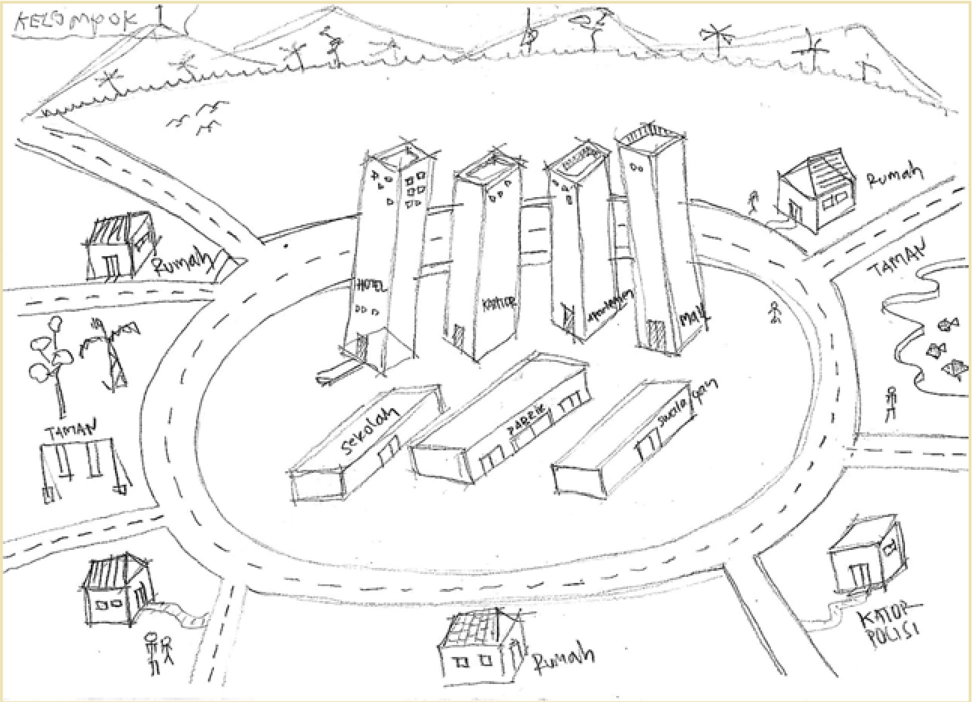
Picture 1 Group 1: Initial Results of Work



Picture 2 Group 2: Initial Results of Work

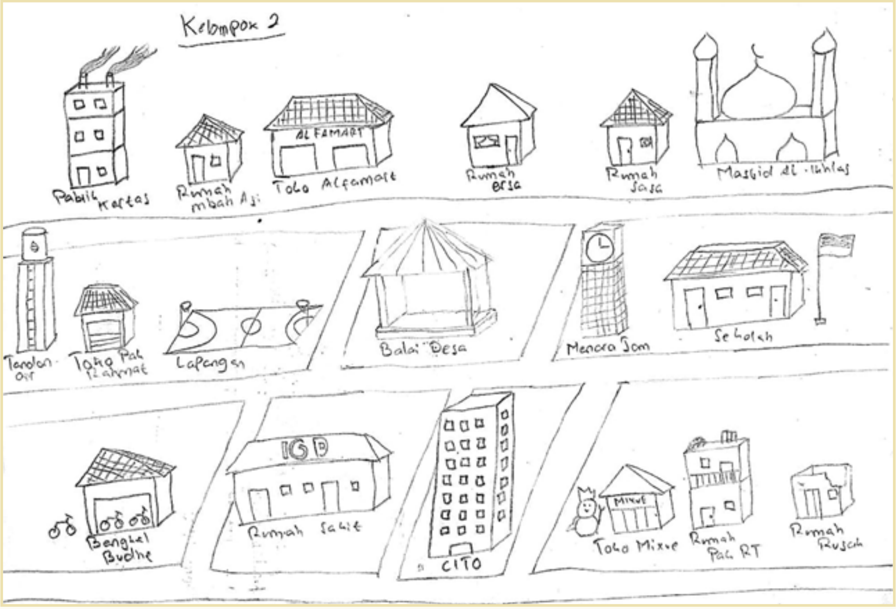


Picture 3 Group 3: Initial Results of Work



Picture 4 Alternative Answers from Group 1

Based on the pictures above, all groups performed well in answering question number 1 (problem-solving section). Each group successfully created a miniature city using 7 cuboids and 5 cubes, designing various types of buildings they named appropriately. However, a common drawback in all groups' drawings was that the edges of the cubes were not perfectly straight, and the dimensions of the cuboids (length, width, and height) were not quite accurate. During the Focus Group Discussion (FGD) after completing the task, I asked whether each group could come up with an alternative solution and add more buildings to assess their fluency. Each group eagerly provided another answer, incorporating additional buildings and varying the placement of the structures compared to their previous designs. All groups were able to create buildings that reflected aspects of learners' daily lives, effectively representing the cuboids and cubes they encountered in a mini city.



Picture 5 Alternative Answers from Group 2

Picture 6 Alternative Answers from Group 3

2. Problem-Posing Section

The problem-posing session continued the following day. All three groups required additional time to work on the second problem, as they engaged in discussions to decide on the problems they would create collaboratively. Group 1 successfully developed a new problem while retaining the original context provided by the researcher. Group 2, in contrast, created a novel problem with a different context, focusing on the sale of cube- and block-shaped items in a shop. Group 3 designed a new problem with a context closely resembling the first problem they had previously addressed.

All groups exhibited a commendable level of creative thinking by generating open-ended problems. Some groups further enhanced their responses by successfully linking the concept of solid geometry to practical, real-world situations. Below are the results of the students' responses to the problem-solving task:

Picture 7. Group 1's Response to the First Problem

"Rani is planning to design a housing estate and has decided to represent the houses using cuboids and cubes. She has three cuboids and five cubes and is seeking help in arranging them to create buildings within the estate"

Picture 8. Group 2's First Question Result

"Andi has twelve identical cuboids and nine cubes, which he plans to use to construct a small town. He is seeking assistance in designing a creative and diverse city"

Picture 9. Group 3's Response to the First Problem

"Draw the objects you would like to place in your room, making sure they are composed of a combination of cuboids and cubes. Be sure to provide names for each object"

When the groups were asked to create a more challenging problem during the FGDs, all of them seemed frustrated and became noisy as they struggled to come up with a new, more difficult problem in a different context. Despite the difficulty, they remained eager to generate another distinct problem and successfully worked on the one they had created.

Another questions from Group 1

"Bastian intends to design a room using cuboids and cubes. He has four cuboids and four cubes. Draw the objects in Bastian's room and identify the shapes of the objects in the picture"

Another questions from Group 2

"Mr. Eri plans to build a new zoo in Surabaya and has plenty of space for the project. He has cubes, cuboids, cones, and tubes at his disposal. Using ten cubes, twelve cuboids, five cones, and seven tubes, design the zoo by constructing animal cages, a playground, an ice cream shop, and an aquarium. Combine these shapes to create three buildings, each incorporating all the different shapes"

Another questions from Group 3

"Mr. Arif, an architect, is designing a playground using six cubes, eight cuboids, and two tubes. Help Mr. Arif by drawing a representation of the playground based on these shapes"

DISCUSSION

1. Creative Thinking Ability

Based on the research findings mentioned above, several important aspects can be identified regarding students' creative thinking abilities, specifically the indicators, which include:

a. Fluency

Fluency is the ability to generate a variety of solutions or new problems. In the problem-solving section, Group 1 presented two different solutions, both correct and well-explained. Group 2 also offered two distinct solutions, each properly explained. Similarly, Group 3 provided two different solutions, both accompanied by clear explanations.

In the problem-posing section, Group 1 created two distinct problems, both of which were correctly solved. Group 2 also posed two unique problems, both answered correctly. Similarly, Group 3 posed two different problems, and both were appropriately solved.

b. Flexibility

Flexibility refers to the ability to generate multiple ideas from various perspectives. In the problem-solving section, Group 1 provided two correct answers from the same perspective. Group 2 offered two correct answers from different perspectives, and Group 3 also gave two correct answers from different perspectives. In the problem-posing section, Group 1 proposed two problems as requested, but both were from the same perspective. Group 2 proposed two diverse problems, both of which were answered appropriately. Similarly, Group 3 proposed two diverse problems, and both were answered correctly.

c. Novelty

Original thinking refers to the ability of students to generate ideas that are distinct and unconventional. In the problem-solving section, Group 1 provided two solutions, but these were not original or different from typical approaches. Group 2 offered one unique solution that deviated from the usual response. Group 3 presented two answers that were original and distinct from the typical solutions. In the problem-posing section, Group 1 proposed a new problem; however, it lacked originality, although it was answered correctly. Group 2, on the other hand, proposed a new and unique problem, which was also answered well. Similarly, Group 3 proposed a new problem that was not unique but was answered correctly.

The groups' creative thinking levels were categorized as follows: Group 1 at Level 2 (Quite Creative), while Groups 2 and 3 reached Level 4 (Very Creative). This indicates effective collaboration in Groups 2 and 3. In the "Very Creative" category, students clearly identified goals, understood problems through discussion, and incorporated real-life data and prior problem-solving experiences. Group 2 initially aimed for more complex problems but ultimately created moderately difficult ones with similar contexts. Despite this, they successfully solved divergent problems by synthesizing mathematical knowledge and personal experiences.

Silver asserts that students with high levels of creative thinking typically demonstrate the ability to generate a wide range of ideas, apply diverse approaches to problem-solving, and develop unique ideas with considerable detail [39]. Lubart further elaborate that elements of creative thinking, such as fluency, flexibility, and originality, are interrelated within the creative process [31]. Students who exhibit fluency can generate numerous ideas, showcasing their quick thinking and efficiency in idea generation. Flexibility enables students to shift between different categories of ideas or strategies, allowing them to approach problems from various perspectives. Originality empowers students to produce unique and unconventional ideas, while elaboration enables them to expand and refine those ideas in greater detail.

At Level 2, students in Group 1 tend to develop ideas primarily based on mathematical concepts, synthesize these ideas, and then apply them. These two groups are also capable of incorporating real-life contexts into both their problem-solving responses and the problems they pose. On average, students at Level 2 faced challenges in introducing novelty into the new problems they created. Group members generated ideas for new problems based on their personal experiences and answered questions using the concepts they had learned. Most indicators of creative thinking were more apparent in problem-solving than in problem-posing, particularly in the aspect of novelty, as observed by AFI from Group 3 below:

P: "Which is more difficult, Problem number 1 or 2?"

AFI: "Obviously, question number 2, ma'am. It's harder to make questions than to answer them"

Some students from other groups also mentioned that posing problems is more challenging than solving them. They explained that solving problems does not require them to focus on the structure of the problem, and because it is a more familiar task, they typically find a solution. This tendency reflects varying levels of creative thinking. However, this does not necessarily mean that a student in a higher-level group, who claims that creating a problem is more difficult than solving it, should automatically be considered to have a higher level of creative thinking. The classification depends on the student's ability to demonstrate key components of mathematical creative thinking.

2. Collaboration Within Each Group

a. Establishing and maintaining a shared understanding

In Group 1, high-ability students (H1) led problem-solving and problem-posing tasks by explaining them to medium- (M1) and low-ability students (L1). However, collaboration was minimal, as discussions were infrequent, and tasks were primarily completed individually before being reviewed together. Group 2 demonstrated stronger collaboration. The high-ability student (H2) ensured all members understood the tasks, explaining concepts and checking comprehension. Brainstorming for problem-posing was done collectively, with L2 recording ideas. Regular discussions and reflections helped reinforce learning, with H2 revisiting explanations when needed. In Group 3, low-ability students (L3) actively sought guidance from high-ability students (H3), while medium-ability students (M3) also participated in explanations and corrections. Discussions were held periodically with evaluations, allowing the group to compare and refine their solutions, though interaction was not as structured as in Group 2.

b. Taking appropriate actions to pose problem

Group 1's approach to problem-solving and problem-posing was to refer to the book and seek clarification from the teacher on how to create new problems. Group 2's plan for the problem-solving task began with reading the problem together to fully understand it, followed by clarifying the questions and defining the meaning of the task. Afterward, the group members brainstormed ideas and assigned tasks, such as who would draw the cuboids and cubes for Problem 1. For Problem 2, Group 2 worked collaboratively, as they preferred not to work separately. Initially, high-ability students (H2) took the lead in finding solutions, but the entire group worked together to define the concept of the problem by gathering examples from books and worksheets. They then modified the given problems to create their own. Even low-ability students were given the responsibility to propose new problems. Once each member had created their problem, the group reviewed them collectively to select the best one.

Group 3's strategy for problem-solving involved dividing tasks among members. The high-ability student (H3) was assigned to work on Problem 2, which focused on problem submission, and their solution was reviewed collectively. Meanwhile, the medium-ability students (M3) and low-ability students (L3) were tasked with solving Problem 1 (problem-solving), and their work was also checked together afterward.

c. Establish and maintain group organization

Group 1 demonstrated a minimal level of group organization. The medium-ability student (M1) and low-ability student (L1) often observed the high-ability student (H1) working, and only when the high-ability student (H1) encountered difficulties did they seek help from the medium-ability student (M1).

In contrast, Group 2 created a positive learning environment with effective collaboration. The equitable distribution of tasks and mutual assistance, particularly in overcoming conceptual difficulties, fostered a strong sense of cooperation. This inclusive approach ensured that all group members were actively engaged in both the problem-solving process and the development of practice questions

Group 3 employed a task division strategy based on members' abilities. Medium-ability students acted as facilitators, proposing initial ideas and coordinating group tasks. High-ability students took the initiative to modify the problem, while low-ability students actively contributed by offering ideas. The problem-solving process in Group 3 was highly collaborative, with all members participating in discussions and the finalization of solutions.

Based on collaboration indicators, Group 1 is classified as Level 3, Group 3 as Level 4, and Group 2 as Level 5. Group 1's Level 3 classification stems from the high-ability student (H1) making key decisions on direction, content, and strategy independently, without consensus from other members. This dynamic was evident as other group members relied on H1's leadership in answering questions.

P : *How do you approach solving the problems provided by the teacher?*

BAA : *I start by attempting to solve it on my own, and then we discuss whether* *the others agree with my solution.*

P : So, is the decision-making process based on mutual agreement?

MM : You should ask BAA, she's the most knowledgeable, Ma'am.

AAP : Yes, Ma'am. Both of us contribute suggestions, but ultimately, BAA determines which solution is the most accurate.

Thus, while the group shares responsibility for collaboration, the decision-making process is not collective; instead, it is the high-ability student who determines the direction.

Group 3 operates at Level 4, where collective responsibility is shared, and significant decisions regarding the content, process, or outcomes of their tasks are made. However, their work remains independent, and interdependence is not evident. While all group members actively participate in decision-making and share responsibility for the outcome, each student's work is autonomous and does not rely on the contributions of others. This coordination in decision-making contrasts with the independence of individual tasks, where the results of one member's work do not directly affect the work of others. This dynamic can be illustrated by the following conversation.

P : "Did you solve the problems assigned by the teacher through discussion, or did you work independently?"

AFI : "The medium-ability students (M3) and low-ability students (L3) were assigned to work on Problem 1, while the high-ability students (H3) focused on Problem 2. However, we discuss all the results collectively afterward."

ADA: "Yes, if there are any errors or aspects that need revision, we address them collectively at the end."

P : "Is the outcome determined by one member of the group?"

AFI : "No, we all participate in the review process together."

Group 2 is the only group that achieved Level 5, characterized by shared responsibility, substantive decision-making regarding the content, process, or product of their work, and interdependent tasks. The group consistently begins their work by reading the problems together. In the problem-solving section, tasks are evenly divided, with specific roles assigned, such as drawing the block and the cube. When the low-ability student (L2) struggles to distinguish between the cube and the block, the high-ability student (H2) and the medium-ability student (M2) dedicate time to teaching them until they fully understand. Additionally, they compile a list of various structures that can be created using cubes and cuboids.

In the problem-posing section, the group collaborates by consulting additional resources, such as books and worksheets, sharing ideas, and individually creating problems. They then collectively select one of their creations to discuss, refine, and develop into a well-crafted question. This collaborative effort is exemplified in the following dialogue:

P : "Did you approach the problems assigned by the teacher collaboratively through discussion, or did you work on them independently?"

AYA : "No, we discussed from the beginning to solve it together."

P : "How did the discussion take place?"

AYA : "In the problem-solving section, we divided the tasks evenly, assigning who would draw the cuboid and the cube."

P : "Is that correct, AR and MPN?"

MPN: "Yes, Ma'am. When I had difficulty distinguishing between the cube and the cuboid, AR and AYA helped me until I understood."

P : "What about Problem 2?"

AYA : "We worked on it together, and then each of us tried to create our problems before we selected one together."

Several factors influence collaborative problem-posing activities in class, including group communication, dynamics, task design, individual student characteristics, social skills, interactions, and diversity of perspectives [40]. Effective communication within the group is critical for successful collaboration. Clear, open, and constructive communication enables students to share ideas, articulate their thoughts, and provide meaningful feedback to one another.

Students' ability to collaborate effectively is significantly influenced by their social skills, such as listening, teamwork, and conflict management. Those with strong social skills are generally more adept at collaborating and contributing to problem-posing tasks. Group dynamics such as role distribution, active participation from all members, and the ability to manage differing opinions play a crucial role in determining the quality of problem-posing outcomes. Groups with healthy dynamics are often more productive and capable of generating creative ideas.

Additionally, the two Level 5 groups demonstrate a high degree of cooperation, characterized by shared decision-making responsibilities and interdependence among members. Indicators of this include strong group cohesion, effective communication, a high level of mutual trust, and reliance on each other's contributions [41; 42] .Group 2 exemplifies these qualities, showcasing the best group dynamics compared to the other two groups. Despite having members with lower mathematical abilities, Group 2 maintains balanced and robust collaboration. This group's diversity serves as an asset, enhancing the outcomes of their problem-posing tasks. Miller highlight that diversity enriches the problem-posing process by incorporating a broader range of perspectives [27].

Group 3 also demonstrated the ability to collaborate effectively and make substantive joint decisions regarding their problem-posing tasks. Their effective communication, underpinned by mutual respect, clear exchanges, and a shared understanding of the task objectives, contributed to their success [43]. Although the tasks in Group 3 were not interdependent, the group maintained collective responsibility for final decisions regarding the tasks to be submitted. High-ability students took the lead on the problem-posing task in Problem 2, while low-ability students focused on the problem-solving task in Problem 1.

Collaboration provides students with the opportunity to exchange perspectives and ideas. The discussions within collaborative groups often stimulate the emergence of new ideas, which may not surface during individual work [44]. Through diverse viewpoints, students can enrich each other's understanding, identify creative solutions, and further develop their ideas. This process enhances the quality of problem-posing tasks, particularly in terms of originality, flexibility, and the detail of the ideas presented. Observations and analyses indicate that groups working collaboratively tend to generate more varied and innovative problems compared to those working individually. The group discussions encourage students to think beyond conventional patterns, fostering the creation of more complex and creative mathematical problems. This aligns with Albert Bandura's social learning theory, which asserts that students can learn from observing how their peers think and solve problems [45]. The social interactions within groups allow students to internalize new skills and strategies that can be applied to group tasks. Additionally, Vygotsky's concept of the Zone of Proximal Development (ZPD) suggests that students can achieve higher levels of understanding and skill when assisted by peers or more knowledgeable individuals. Collaboration, therefore, enables students to tackle more complex tasks than they could on their own [46].

In collaborative groups, fluency can be enhanced through brainstorming sessions that involve multiple participants. The dynamic discussion process allows group members to inspire one another, enabling them to generate more ideas collectively. With encouragement and feedback from other group members, students become more motivated to continue developing new ideas. However, it is crucial for the group to manage time effectively and maintain focus to ensure that this fluency is directed toward generating quality outcomes, rather than merely a large quantity of ideas. Collaboration also fosters flexibility, as each group member brings unique perspectives and approaches to a problem. Interactions within the group prompt students to consider alternative solutions and ways of thinking that may differ from their initial ideas. Open discussions enable the group to explore various ways of posing problems and adapting ideas based on input from other members, enriching their ability to pose problems in a more varied and adaptive manner.

Overall, the variation in collaborative problem-posing levels among student groups highlights the complexity of group work and underscores the importance of fostering effective communication, mutual respect, and shared responsibility within collaborative learning environments. By understanding the factors that contribute to successful collaboration, teachers can better support students in developing their collaborative problem-posing skills and maximizing the benefits of working together in groups.

CONCLUSION

In this study, all groups demonstrated a solid understanding of the problem-solving task by successfully constructing cuboids and cubes to form mini-cities with various types of buildings. While slight imperfections were observed in the shapes of the cubes and cuboids, the groups showcased creativity by effectively naming the buildings. During the follow-up discussion, all groups successfully created new problems based on the original task, illustrating critical and creative thinking. Group 1 retained the original context of the task, whereas Groups 2 and 3 adapted the problem into new contexts, demonstrating the practical application of solid geometry in real-world scenarios. These outcomes highlighted strong creative thinking abilities across the groups, with fluency and flexibility especially evident in their capacity to generate diverse ideas and approaches.

However, further efforts are required to foster greater novelty and originality in problem-solving and problem-posing tasks. Several key factors influence the success of collaborative problem-solving activities. Effective communication plays a pivotal role, enabling students to share ideas, articulate thoughts, and provide constructive feedback. Social skills, such as active listening, teamwork, and conflict management, are essential for fostering collaboration and empowering students to contribute more effectively. Additionally, group dynamics—including the equitable distribution of roles, active participation, and the resolution of differing opinions—significantly impact creativity and productivity within groups. Teams with positive dynamics are more likely to generate innovative solutions and achieve superior outcomes. These findings underscore the importance of creating a collaborative learning environment that emphasizes clear communication, social interaction, and healthy group dynamics. Such an environment can maximize students' creative problem-posing abilities and contribute to more effective learning.

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