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Exploring Gender Differences in Middle School Students' Creative Approaches to Open-Ended Geometry Problems

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ABSTRACT

Creativity is an important skill in 21st century education. Student creativity can be measured, among other things, through open-ended questions. Gender differences are one factor that influences creativity. The difference between masculine male creativity and feminine female creativity has always been a subject of debate. Researchers measured how female and male students' creativity in solving open-ended geometry problems. In this study, feminine female students showed greater flexibility, as evidenced by their work, which included six variations of solutions. Male students showed novelty, as evidenced by new variations of solutions according to junior high school students. This study supports research that states that there are differences between the creativity of female and male students in solving open-ended problems.
Keywords: creativity, open ended problems, geometry, gender differences

Kreativitas Siswa SMP dalam Pemecahan Masalah *Open Ended* Geometri Berdasarkan Perbedaan Gender

ABSTRAK

Kreativitas adalah kemampuan yang penting pada pendidikan abad ke-21. Kreativitas siswa dapat diukur salah satunya melalui soal *open ended.* Perbedaan gender menjadi salah satu tinjauan yang mempengaruhi kreativitas. Perbedaan kreativitas laki-laki maskulin dan Perempuan feminine selalu menjadi perdebatan. Peneliti mengukur bagaimana kreativitas siswa perempuan dan siswa laki-laki dalam memecahkan masalah open-ended geometri. Pada penelitian ini siswa perempuan feminine menunjukkan fleksibilitas yang lebih dibuktikan dengan hasil pekerjaan yang mencakup enam variasi penyelesaian. Siswa laki-laki menunjukkan novelty ditunjukkan dengan variasi penyelesaian yang baru menurut siswa SMP. Penelitian ini mendukung penelitian yang memiliki pernyataan bahwa terdapat perbedaan antara kreativitas siswa perempuan dan siswa laki-laki dalam memecahkan soal open-ended.
Kata Kunci: *kreativitas, masalah open ended, geometri, perbedaan gender*

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1. Introduction

Creativity in mathematics is an essential 21st-century competency that reflects students' ability to generate diverse, flexible, and original solutions (Guilford, 1967; Silver, 1997). Mathematical creativity is not only the capacity to arrive at correct answers, but also includes the ability to develop new ideas, explore various approaches, and construct meaningful, non-routine solutions (Torrance, 1974; Siswono, 2008; Eren, 2021). Open-ended problems are particularly effective in nurturing creativity because they allow multiple correct responses and encourage students to reason independently, explore possibilities, and present unique solutions based on their personal understanding (Islam et al., 2021; Septiwulan & Ismail, 2024; Schoevers et al., 2021).

Geometry, as one of the fundamental domains of mathematics, makes a strong contribution to creative development due to its visual-spatial nature and the requirement to analyze relationships between shapes and structures (Battista, 2007; Clements & Sarama, 2009; Ramírez-Uclés & Ramírez-Uclés, 2020; Wulandari et al., 2024). When geometry is presented in the form of open-ended tasks, such as land division, pattern creation, or geometric figure construction, it activates students' spatial reasoning, imagination, and representation skills. These tasks support the emergence of key dimensions of creativity: fluency, flexibility, and originality (Silver, 1997; Schoevers et al., 2021).

Gender distinctions can shape the ways in which students' express creativity when tackling mathematical problems. As Lips (2019) argues, gender is socially constructed through cultural expectations and norms, which may influence how learners engage with academic tasks. Empirical studies suggest that boys generally display a more systematic approach, whereas girls often show greater reflectiveness, a distinction that affects their participation in creative mathematical reasoning (Hyde, 2005; Islam et al., 2021). Rosyidi et al. (2025) showed that students' gender influences the strategies and techniques they choose in solving geometry problems. Furthermore, In addition, psychological or social factors such as gender differences are among those that can influence creative performance (Lips, 2019; Mejía-Rodríguez et al., 2021; Real & Carvalho, 2025). Furthermore, the OECD highlights the importance of creativity in 21st-century education (OECD, 2013). Therefore, further research is needed into creativity in solving open-ended geometry problems from a gender perspective.

However, only a few studies focus directly on how middle school students show creativity when working on open-ended geometry tasks. This gap highlights the need for deeper exploration in that area. This study therefore seeks to fill that gap by examining students' creativity in handling open-ended geometry tasks, with a focus on gender-related differences in fluency, flexibility, and originality, contributing to the advancement of more inclusive and adaptive approaches to mathematics education (Islam et al., 2021; OECD, 2013).

Creativity itself can be understood as the capacity to produce ideas, methods, or products that are both original and valuable across fields such as education, business, and the arts. It typically involves two fundamental components: novelty, referring to something distinct from prior ideas, and usefulness, which highlights its relevance in a specific context. Guilford (1967) identified divergent thinking, the ability to generate a wide range of ideas, as a central feature of creativity. Stein (1953) further noted that creative ideas must have practical value and contribute to problem-solving. Building on these perspectives, Amabile (1983) proposed that creativity is shaped by three essential factors: domain-specific knowledge and expertise, creative cognitive processes, and intrinsic motivation.

Runco & Jaeger (2012) state that the two main criteria for determining whether an idea or product can be called creative are novelty and acceptability. This means that in addition to being different from what already exists, the idea must also be considered appropriate or relevant in a particular context. Thus, creativity is not only a matter of personal originality, but also the relevance of the context to the idea. This is important because many ideas are original but not accepted or relevant in practice.

Torrance (in Kaufman & Sternberg, 2022) sees creativity as a process that can be taught and developed. Torrance focuses on measuring creative thinking through fluency, flexibility, originality, and elaboration. Torrance also emphasizes the importance of a supportive environment, where individuals feel safe to express their ideas without fear of being wrong.

In the context of the multidimensionality of creativity, some researchers give different emphasis to the main elements that make up creativity. Amado et al. (2018) highlighted creativity as a combination of originality, precision, and effectiveness. They emphasized that a creative idea must not only be novel but must also be able to be applied effectively in solving problems. Acar et al. (2017) emphasized the importance of the elements of originality, surprise and value in creativity, where an idea is called creative if it can generate unexpected responses that are of high value. They argue that surprise is a strong indicator of an unconventional thought process. Furthermore, Silver (1997) states that creativity can be recognized through three main characteristics, namely fluency (fluency in generating many ideas), flexibility (flexibility in thinking from various points of view), and novelty (novelty that produces original ideas).

Open ended problems are a type of problem that provides room for more than one correct answer and allows for various solution strategies (Silver, 1997; Leikin & Lev, 2007). These problems are different from closed problems because they encourage students to think freely, explore possibilities, and express mathematical ideas personally (Siswono, 2008). In mathematics learning, open-ended problems have been shown to be effective in developing critical and creative thinking skills, as well as increasing student engagement in the learning process (Eren, 2021).

Open-ended mathematical tasks particularly in the domain of geometry serve as effective pedagogical instruments for fostering students' creativity and higher-order reasoning. Such problems require learners to construct multiple acceptable solutions, work within uncertain conditions, and combine both general creative thinking abilities with subject-specific mathematical knowledge (Bingölbali & Bingölbali, 2021; Schoevers et al., 2021).

Gender differences in mathematics are not absolute. They do not stem from biology alone but from culture, society, and prior learning (Leder, 2019). Importantly, gender is not the same as sex. Both boys and girls may think in ways that appear "masculine" or "feminine" depending on the solving task (Bem, 1974). This means that studies and teaching practices should remain neutral and inclusive. Teachers, therefore, need to design environments that encourage every student to use and grow their creative potential (Lips, 2019; OECD, 2019).

2. Methods

The purpose of this study was to explore junior high school students' creativity in solving open-ended geometry problems with a gender perspective. Two junior high school students, one masculine male student and one feminine female student, participated in this study. The research instruments were a gender questionnaire and problem-solving tasks. Data were collected through geometry problem-solving tasks designed to explore students' creative thinking, a BSRI questionnaire to classify gender-role orientation, and semi-structured interviews conducted to obtain in-depth information about students' reasoning and problem-solving processes. The problem-solving tasks were validated by a mathematics education expert and a mathematics teacher at the school, while data validity was ensured through triangulation. Data analysis was conducted using Silver's indicators of mathematical creativity—fluency, flexibility, and novelty—and followed Miles, Huberman, and Saldaña's (2014) interactive model, consisting of data condensation (simplifying, focusing, and organizing raw data from tasks and interviews), data display (presenting data systematically in tables, charts, or narratives), and conclusion drawing/verification (interpreting findings, checking consistency, and confirming validity).

3. Results and Discussion

The findings of this study are presented according to Silver. (1997) indicators of mathematical creativity, namely fluency, flexibility, and novelty. Each indicator is described separately to show how the students demonstrate creative thinking in solving the open-ended geometry problem. The presentation begins with the feminine female student, followed by the masculine male student. For each student, the analysis is based on problem-solving tasks and interview data, which provide insights into their strategies, reasoning processes, and creative approaches.

3.1 Creativity of Feminine Female Junior High School Students in Open Ended Geometry Problem Solving

In the results section, the study outlines how the two participants engaged in creative thinking while addressing the open-ended geometry task. The analysis is structured around Silver's dimensions of fluency, flexibility, and originality, highlighting the distinct ways each subject approached the problem. The subsequent subsection provides a detailed account of the feminine female student's work, emphasizing the strategies employed, the reasoning applied at each stage, and the creative elements evident in her solutions.

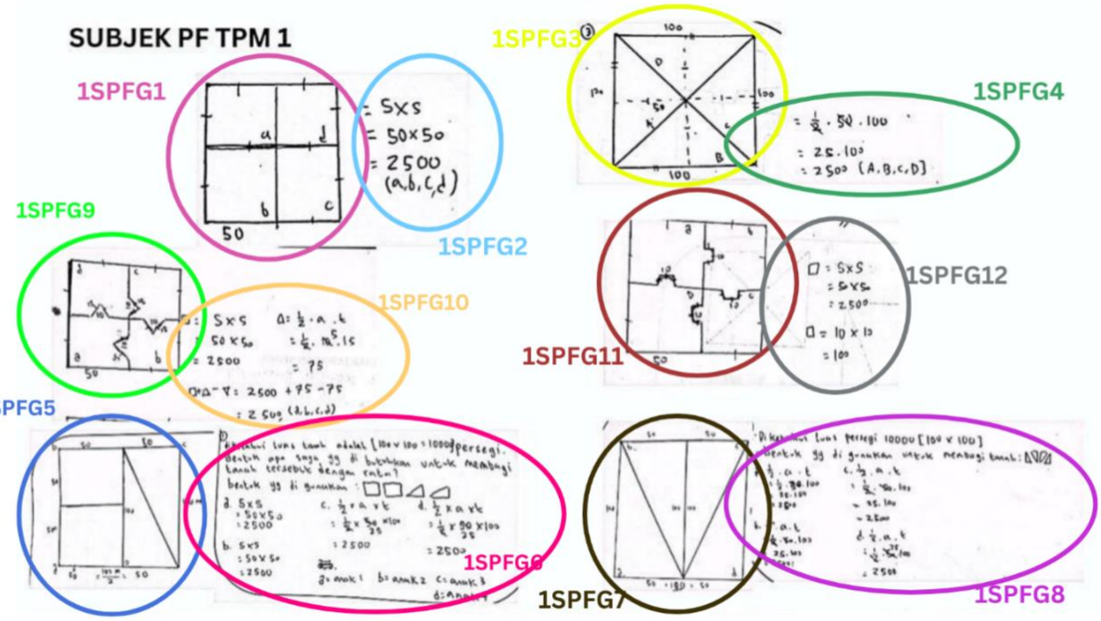

Figure 1. the results of the feminine female subject's problem solving test

The presentation of findings in this study follows Silver (1997) framework of mathematical creativity, which includes the components of fluency, flexibility, and originality. Each element is examined in depth to demonstrate the ways students displayed creative thinking in addressing the open-ended geometry task. The analysis opens with a focus on the fluency aspect. Fluency refers to the ability to produce numerous alternative solutions within a limited time (Guilford, 1967). In this regard, the feminine female student demonstrated strong fluency in her problem-solving process, as shown in the following description.

3.1.1 Fluency

Fluency refers to the ability to produce numerous alternative solutions within a limited time (Guilford, 1967). Feminine female students demonstrate the fluency component of creativity, which is the ability to generate many alternative solutions in a short time (Guilford, 1967). In solving the open-ended geometry problem, the subject was able to develop six different strategies to divide the square land into four equal parts. The first strategy began with dividing the land using vertical and horizontal lines into four small squares (ISPFG1), then moving on to the second strategy of dividing into four identical triangles through two diagonal lines (ISPFG3). Furthermore, the subject developed a third, more complex strategy, namely a combination of two squares and two triangles that showed integration between two different geometric shapes (ISPFG5). The variety of strategies was further developed through a hybrid approach, namely by dividing the land into two large parts first, then forming four triangles from the continued division. The subject also displayed another strategy by combining large square and small square shapes as a new attempt in achieving consistent results.

The subject's ability to move from one strategy to another and develop new forms legitimately shows the fluency aspect in the context of mathematical creative thinking. Fluency is reflected in the fluency of generating various solution ideas that remain mathematically consistent, namely each section remains 2500 m^2. This finding is in line with Guilford (1967) and Torrance (1974) theories, which emphasize that fluency is a key indicator of creativity because it reflects the productivity of rapid and diverse ideas. Silver (1997) also emphasized that in mathematics, fluency is shown through the ability to produce many valid solutions to non-routine problems such as open-ended problems. In this context, the results showed that students did not stick to one form of representation, but rather explored various possible solutions with high flexibility, such as the use of symmetrical and asymmetrical dividing lines and a stepwise approach in visualizing space.

The alignment between these findings and prior research is also evident. Leikin & Lev (2007), in Educational Studies in Mathematics, reported that highly creative students could produce multiple valid and distinctive solutions to open-ended geometry problems a result echoed in the strategies demonstrated by the participants in this study. Supporting this, Septiwulan & Ismail (2024) observed that learners with feminine orientations often engage in broader exploration of ideas when addressing visual spatial tasks. Likewise, Ferdiani et al. (2022) found that the capacity to employ diverse strategies in geometry is closely associated with cognitive flexibility and a strong conceptual grasp.

3.1.2 Flexibility

Silver (1997) explains that flexibility is related to a person's ability to change perspectives and try various strategies when facing problems. In this study, subjects demonstrated this flexibility by moving from one geometric shape to another when solving open-ended problems. Subject did not stick to just one method but tried various cutting patterns. Subject divide squares by vertical and horizontal lines, triangles through diagonals, and combinations of squares and triangles. This change in strategy can be seen from the sequence of answers: division into four squares (ISPFG1), four triangles (ISPFG3), a mixture of squares and triangles (ISPFG5), and four triangles through gradual division (ISPFG7).

Interestingly, in the ISPFG5 and ISPFG7 strategies, it can be seen that the subjects not only followed the general procedure but also combined and modified the shapes so that the area remained the same. This pattern is in line with the framework of Wang and Star (2023), which distinguishes algorithmic flexibility from structure-based flexibility. The subjects fall into the second category, namely being able to adjust and redesign geometric elements more freely. This was also confirmed by Li et al. (2020), who stated that flexibility is demonstrated through the ability to select, replace, and rearrange strategies. In this study, the subjects did this when they divided the shape into identical triangles to maintain the same area.

3.1.3 Novelty

This dimension highlights the originality or distinctiveness of the solutions, which surpass standard approaches and demonstrate fresh perspectives or inventive reasoning (Leikin & Lev, 2007). In this study, the subject exhibited novelty by devising an original method to partition the square plot into four regions of equal area. One form of novelty was seen in the fifth strategy, when the subject combined two geometric shapes - a square and a triangle - in one solution. This approach involved using two large squares supplemented by the addition of one small square and one triangle on opposite sides. This strategy differs from the previous patterns that used only one type of flat shape. The modification of the division marks a shift from the earlier, more conventional approach towards compositions that contain more than one shape structure. The emergence of this strategy indicates an indicator of novelty, which is generating ideas in a way that is not commonly found in the original strategy. Novelty in this context refers to the creation of a variety of shapes resulting from the utilization of different cutting lines and varying wake positions (Torrance, 1974). The subject did not repeat the previous strategy but came up with another shape with a combination of horizontal and diagonal lines and additional small planes placed on certain sides. This shows a new form of idea in the visual representation pattern. According to Guilford (1967), novelty appears when a person creates alternative solutions that are different from most others by using available elements. In this case, the use of additional small shapes and combinations of shapes shows an exploration of effort in creating new shapes from the same source.

3.2 Creativity of Masculine Male Junior High School Students in Geometry Open Ended Problem Solving

This section presents the results of how the two participants used creative thinking in solving the open-ended geometry task.

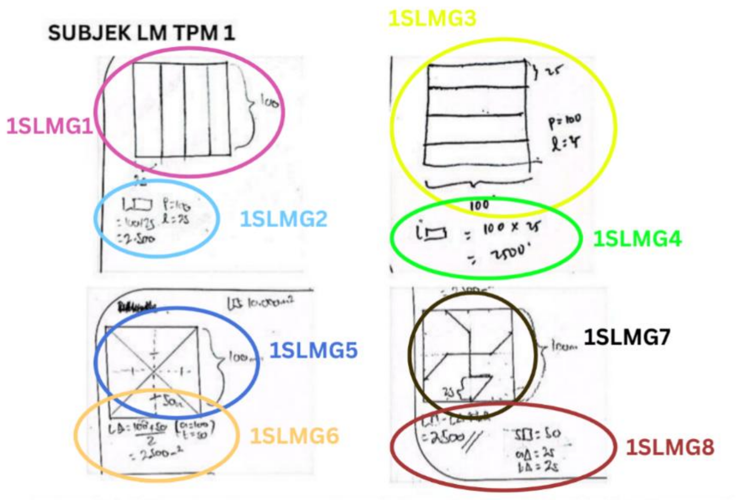

Figure 2. the results of the masculine male subject's problem solving test

The results of this research are structured according to Silver (1997), framework of mathematical creativity, which encompasses fluency, flexibility, and novelty. Each element is examined thoroughly to demonstrate how students displayed creative reasoning in tackling the open-ended geometry task. The discussion begins with the fluency component. Fluency refers to the ability to produce numerous alternative solutions within a limited time (Guilford, 1967). In this regard, the masculine male student demonstrated strong fluency in his problem-solving process, as shown in the following description.

3.2.1 Fluency

The subject showed fluency in creative thinking by producing four different strategies in dividing a square land (100 m × 100 m) into four equal-area parts, namely through vertical and horizontal division into four rectangles (100 m × 25 m), four triangles (base 100 m, height 50 m), and a combination of one small square (50 m × 50 m) and two small triangles (base 25 m, height 25 m). These strategies were produced in a short period of time with the consistency of precise area calculations. This finding reflects Torrance's (1974) and Silver's (1997) indicator of fluency, which is the ability to generate a variety of ideas within a limited time. Masculine male students showed not only the quantity of alternatives, but also the diversity of geometric structures as a form of flexibility in shape exploration.

Furthermore, Leikin & Lev (2007) emphasized that multiple solution tasks such as open ended problems can display the potential of mathematical creativity through the variety of strategies developed by students. In this context, the subject was able to solve one problem with four different approaches that were all mathematically valid. The subject's success shows that the fluency aspect is not only related to the number of solutions but also reflects the depth of exploration and the ability to move between various valid geometric representations.

3.2.2 Flexibility

The subject showed creative flexibility by attempting several ways to divide a square into four equal parts. He started with vertical and horizontal rectangles, then moved on to four triangles, and later tried a combination of a small square with two triangles. This shift from rectangles to triangles and finally to mixed shapes demonstrated his ability to move across different categories of geometric figures and to reorganize solutions effectively.

These results are consistent with the findings of Pradiarti et al. (2024), who observed that students with high fluency in open-ended geometry tasks tended to generate a variety of strategies with distinct visual representations. Guilford (1967) described this as operational flexibility.

Wang & Star (2023) distinguish between procedural flexibility and structure-informed flexibility in mathematics learning. They argue that flexible thinkers not only have multiple strategies but also know how to adapt them to the visual structures and demands of the task. Subject rotating rectangles or combining square and triangle pattern. He illustrated this adaptability, as his choices were shaped by representational needs. Yang et al. (2019) also emphasized that visual-spatial flexibility appears when learners adjust their strategies in response to structural changes in a problem. This was evident when the subject shifted among different geometric configurations while still ensuring that all sections had equal area.

3.2.3 Novelty

In one of the solutions, the subject integrated two distinct geometric figures—a small square (50 m × 50 m) and a small triangle (base 25 m, height 25 m) to partition the larger square land into four equal regions. This combination was more than a mere visual alteration; it reflected a reconstruction of ideas grounded in spatial intuition, as the subject envisioned the sides of the square being "folded" to create a triangular form. In the context of creative thinking, this strategy reflects the novelty indicator because the idea did not come from a general pattern or example that had been given but rather came independently. According to Guilford (1967) and Silver (1997), novelty or originality is characterized by ideas that rarely appear, unusual, but still conceptually valid. Novelty is also supported by Leikin & Lev (2007) research which shows that novelty in mathematical problem solving is not only seen from different final results, but from how students build unexpected connections between geometric concepts.

3.3 Comparison of Creativity of Feminine Female and Masculine Male Junior High School Students in Solving Open Ended Geometry Problems

Feminine female students showed greater flexibility than masculine male students. This was evidenced by the students' work, which provided six alternative solutions. Meanwhile, male students produced four alternative solutions. This suggests that feminine female students are more explorative, generating a greater number of alternative solutions within a limited time, which aligns with Torrance's (1974) view that fluency reflects the breadth of idea generation, and is consistent with Islam et al. (2021) who reported that female students tend to explore more extensively in open-ended tasks.

In flexibility, feminine female students moved across a wider range of geometric shapes (square, triangle, combination) and division orientations (vertical, horizontal, diagonal), whereas masculine male students concentrated on three main shapes: rectangle (two orientations), triangle, and square-triangle combination. Both demonstrated flexibility in reorganizing solution structures, but feminine female students exhibited greater adaptability by experimenting with more categories and orientations. Regarding novelty, feminine female students showed progressive modifications between strategies, creating uncommon shapes in later solutions, while masculine male students produced unique hybrid solutions combining small squares and triangles. In terms of novelty, both students demonstrated originality in their solutions. However, in designing their solutions, the male student produced a more interesting new product (Acar et al., 2017; Torrance, 1974). These distinctions can be understood through the perspective of gender-related cognitive tendencies and learning orientations. It is agreed that female students are more exploratory in seeking solutions. As a result, female students demonstrate greater flexibility and fluency. Male students use unique methods in constructing each solution, demonstrating greater novelty. These findings can be used as a reference in learning. For example, to design open-ended geometry assignments that accommodate all aspects of creativity. Recognizing that feminine female students are more inclined toward generating numerous strategies, while masculine male students tend to prioritize novel outcomes, enables teachers to offer tailored support and scaffolding. Such practices can more effectively cultivate creativity, engage learners, and strengthen higher-order problem-solving skills.

4. Conclusion

This study shows that both feminine female and masculine male students displayed creative thinking in solving open-ended geometry problems. The female student generated six strategies and shifted flexibly across different geometric forms, showing variety in both structure and orientation. In contrast, the male student offered fewer solutions, but they were original and distinctive. These findings suggest that while females tend to explore broadly, males emphasize originality. Creativity, therefore, emerges in different ways across genders.

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