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A Study on Mental Models and Geometric Strategies of Prospective Mathematics Teachers: Dynamics of Triangle and Quadrilateral Representations

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Abstrak

Penelitian ini bertujuan untuk menganalisis model mental dan strategi geometri mahasiswa calon guru matematika dalam merepresentasikan bangun datar, khususnya segitiga dan segiempat. Penelitian ini menggunakan metode deskriptif kualitatif dengan subjek 27 mahasiswa Universitas Negeri Medan tahun akademik 2023/2024. Data dikumpulkan melalui tugas menggambar bangun datar yang mencakup berbagai jenis segitiga dan segiempat, serta dianalisis menggunakan tahapan reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa mahasiswa cenderung menggunakan representasi prototipe dalam menggambar bangun geometri, seperti segitiga siku-siku, sama kaki, dan sama sisi, serta persegi dan persegi panjang. Strategi pembagian bangun juga didominasi oleh pola sederhana seperti pembagian vertikal dan horizontal yang dianggap paling mudah dan efisien secara kognitif. Temuan ini mengindikasikan bahwa model mental mahasiswa masih sangat dipengaruhi oleh pengalaman belajar sebelumnya, prototipe visual, serta beban kognitif dalam proses pemecahan masalah geometri. Secara keseluruhan, kemampuan representasi mental mahasiswa belum sepenuhnya berkembang ke arah pemahaman formal yang fleksibel dan konseptual.

Kata kunci: model mental, geometri, representasi visual, bangun datar, mahasiswa calon guru matematika

Abstract

This study aims to analyze the mental models and geometric strategies of prospective mathematics teachers in representing plane figures, particularly triangles and quadrilaterals. A qualitative descriptive method was employed involving 27 undergraduate students from Universitas Negeri Medan in the 2023/2024 academic year. Data were collected through a structured drawing task covering various types of triangles and quadrilaterals and were analyzed using data reduction, data display, and conclusion drawing techniques. The findings reveal that students predominantly rely on prototypical representations in drawing geometric figures, such as right, isosceles, and equilateral triangles, as well as squares and rectangles. Their partitioning strategies are also dominated by simple approaches, particularly vertical and horizontal divisions, which are considered cognitively efficient and easier to execute. These results indicate that students' mental models are strongly influenced by prior learning experiences, visual prototypes, and cognitive load during problem-solving processes. Overall, students' mental representations have not yet fully developed toward flexible and formal conceptual understanding in geometry.

Keywords: mental model, geometry, visual representation, plane figures, prospective mathematics teachers

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Introduction

Mathematics plays a fundamental role in developing higher-order thinking skills, including logical, critical, creative, and analytical reasoning. As emphasized by Soedjadi (in Aripin & Fitrianna, 2018), mathematics learning in schools is not merely directed toward conceptual mastery, but also toward the ability to apply mathematical

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concepts in solving contextual problems. Among various branches of mathematics, geometry holds a central position in strengthening conceptual understanding due to its strong connection with spatial structures and abstraction processes. Geometry involves the study of relationships among points, lines, angles, planes, and spatial forms (Travers in Farokhah, 2020). Furthermore, Azhar & Senjayawati (2021) highlight that geometry extends beyond concrete constructions such as cubes and prisms, encompassing abstract entities such as points and lines that serve as foundational elements for understanding spatial structures through abstraction.

In both academic and practical contexts, geometry is extensively used in everyday problem-solving activities, ranging from calculating area and perimeter, designing spatial layouts, determining navigation routes, to constructing architectural and digital models. Contemporary technological domains such as computer graphics, geographic information systems, and game development also heavily rely on geometric principles as their conceptual foundation. Despite its importance, empirical studies consistently reveal that university students still experience significant difficulties in understanding and representing geometric concepts, particularly in plane geometry. These difficulties are not limited to conceptual deficiencies but also extend to the inability to construct coherent internal representations when solving geometric problems (Wirahmad & Arifin, 2020; Putri & Feriyanto, 2020). Such conditions indicate that students often struggle to transform abstract mathematical information into meaningful mental representations.

From a cognitive perspective, problem-solving in geometry is strongly influenced by schema activation processes. Schema activation occurs when learners integrate new information with pre-existing knowledge structures stored in long-term memory. In this process, students do not merely recall definitions or formulas but also construct internal representations in the form of mental images that allow them to visualize and manipulate geometric objects. These mental images function as cognitive bridges between abstract mathematical concepts and their visual-spatial representations, enabling learners to understand relationships among geometric elements such as shape, position, and transformation. Moreover, prior learning experiences, including drawing activities, manipulation of concrete materials, and exposure to real-world contexts, significantly enrich the quality of these mental representations.

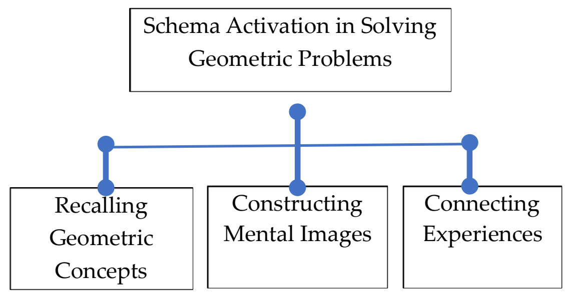

Figure 1. Students' Thinking Process

As illustrated in Figure 1, the thinking process in solving geometry problems is not linear but rather dynamic and integrative through schema activation. This process involves three interrelated cognitive components: recalling geometric concepts, forming mental images, and connecting prior experiences. Recalling geometric concepts refers to the retrieval of declarative and procedural knowledge from long-term memory, such as properties of shapes, angle relationships, and construction rules. This stage provides the conceptual foundation for problem-solving. Subsequently, forming mental images constitutes the core representational process in which students transform symbolic or verbal information into internal visual representations. Through this process, students are able to "see" and mentally manipulate geometric objects without relying on physical aids, thereby supporting the understanding of transformations and spatial relationships. The third component, connecting experiences, plays a crucial role in strengthening cognitive processing by linking new concepts with prior learning experiences or everyday contexts, thereby enriching the construction of mental representations.

These three components operate in an integrated manner to shape students' cognitive structures during geometric problem-solving. Effective schema activation enables the formation of accurate, flexible, and meaningful mental representations, which in turn support systematic reasoning and problem-solving strategies. Conversely, weaknesses in any of these components may lead to cognitive imbalance, resulting in misinterpretation, inaccurate construction of geometric figures, and errors in solving transformation-based problems. Therefore, the model presented in Figure 1 emphasizes that success in geometry learning is largely determined by the quality of interaction among conceptual knowledge, mental image construction, and experiential integration.

Despite the importance of these cognitive processes, existing studies indicate that students' ability to construct and manipulate mental representations remains underdeveloped. Difficulties are particularly evident in maintaining stable and coherent mental images during problem-solving, leading to frequent errors in interpretation and geometric construction. These findings suggest that geometry instruction at the higher education level still requires a stronger emphasis on the development of students' mental representation processes.

Based on this theoretical and empirical gap, the present study aims to analyze the mental models and geometric strategies of prospective mathematics teachers in understanding and representing triangles and quadrilaterals. This study is expected to contribute empirically to the understanding of cognitive processes in geometry learning and to provide a foundation for developing more effective instructional strategies that emphasize the strengthening of mental representations in higher education mathematics learning.

Method

This study employed a qualitative descriptive research design aimed at exploring prospective mathematics teachers' cognitive processes in constructing mental models and geometric strategies when working with plane figures. Specifically, the study investigated students' ability to draw and partition geometric shapes such as triangles and quadrilaterals, as well as their understanding of shape differentiation and equal-part proportional reasoning. The qualitative descriptive approach was chosen to obtain an in-depth understanding of students' thinking processes in geometry. According to Abdurrahman and Moleong (as cited in Aripin, 2018), qualitative descriptive research aims to systematically describe a phenomenon in its natural context and generates data in the form of written or verbal expressions from participants.

The participants of this study were 27 undergraduate students from Universitas Negeri Medan (2023/2024). The object of the study was the analysis of students' mental models and geometric representations in visualizing triangles, quadrilaterals, and a composite shaped figure. The primary instrument used was a structured drawing task involving plane figures, including triangles (isosceles, equilateral, right-angled, and scalene) and quadrilaterals (rectangle, square, trapezoid, rhombus, and parallelogram). Students were instructed to draw each figure manually and divide them into equal parts according to five task prompts. Each response was analyzed based on the accuracy of geometric representation, the strategy used in partitioning, and the consistency between instructions and final outputs.

Data analysis was conducted using qualitative interactive analysis consisting of three stages: data reduction, data display, and conclusion drawing. Data reduction involved selecting and focusing on essential aspects such as geometric accuracy, partitioning strategy, and proportional reasoning. Data display was carried out through tables and simplified visual summaries to facilitate comparison across different geometric tasks and student responses. Finally, conclusion drawing was performed by identifying recurring patterns in students' mental model construction and geometric reasoning processes.

In addition, a didactical design was integrated into the study to activate students' metacognitive processes in visualizing plane figures. This design consisted of three sequential phases. First, the preliminary task phase, in which students were asked to independently draw and partition geometric shapes without procedural guidance. Second, the didactical situation phase, where students were prompted to justify their strategies and respond to metacognitive questions such as why a particular strategy was chosen, whether alternative strategies exist, and how they determined equal partitioning. Third, the reflection and evaluation phase, in which students reviewed their work, compared their solutions with peers, and critically evaluated the strengths and limitations of their strategies. Through this structured sequence, the study aimed to capture how metacognitive activation contributes to the development of mental models and the quality of geometric reasoning in solving plane figure problems.

Result and Duscussion

The results of the study indicate that three mental models were developed by students to solve triangle area problems, namely the initial mental model, adaptive mental model, and formal mental model. Additionally, differences were observed in the strategies employed and the active schemata. The adaptive mental model refers to a mental model that undergoes a process of accommodation and adaptation. Based on the literature review, 27 prospective mathematics teacher students were given a test with the following tasks; (1) draw a triangle, assign it a name (Triangle Model-1), and divide it into four equal parts; (2) repeat the task with a second triangle (Triangle Model-2), assign a name, and divide it into four equal parts; (3) draw a quadrilateral, assign it a name (Quadrilateral Model-1), and divide it into three equal parts; (4) repeat the task with a second quadrilateral (Quadrilateral Model-2), assign a name, and divide it into three equal parts.

The test was designed to assess the following aspects; (1) visual-Spatial Ability and Geometric Creativity; (2) understanding of Area Concepts and Proportions; (3) consistency and Systematic Problem-Solving; (4) Ability to Follow Sequential Instructions (Procedural Skills). The complete results of the students' responses can be seen in Table 1 below.

Table 1. Students' Responses Regarding Triangle Models

Triangle Type	**Number of Triangle Models**		**Total**
	1	**2**	
Right Triangle	3	16	**19**
Isosceles Triangle	13	5	**18**
Equilateral Triangle	11	6	**17**
Scalene Triangle	0	0	**0**
Total Students	**27**	**27**	**54**

The majority of students drew right-angled triangles (19 students), which were predominantly chosen due to their distinctive characteristics and frequent use in geometry problems, thereby strengthening students' visual memory. A significant number of students (18 students) drew isosceles triangles, which have become the most dominant prototypical mental image of triangles in their visual memory. Since elementary education, students are more often introduced to symmetrical, upright, and balanced triangle representations, so these shapes are strongly embedded in their mental models. Consequently, when asked to draw a triangle spontaneously, students tend to reproduce familiar and visually stable shapes rather than scalene triangles, which have irregular sides and angles. This indicates that students' geometric understanding is still largely influenced by

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prototypical visual representations rather than the formal definitions of triangle concepts.

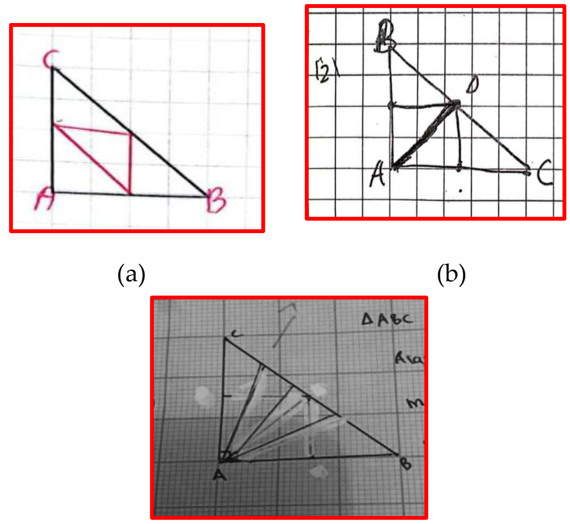
Furthermore, seventeen students drew equilateral triangles, indicating that their mental models are oriented toward shapes considered the most "perfect" or prototypical. The equilateral triangle, being symmetrical, easy to visualize, and frequently appearing in textbooks, has become the dominant mental representation, in accordance with the prototype theory in cognition, which states that individuals tend to use the most ideal example as a representative of a concept.

Students did not choose scalene triangles. Unlike right-angled, isosceles, and equilateral triangles, scalene triangles lack natural lines of symmetry, so dividing them into four equal parts requires more complex calculations. In addition, due to their asymmetry, with sides and angles all differing, scalene triangles cannot be folded into two identical halves. Attempting to partition them without precise calculation is likely to produce pieces of unequal area, increasing the risk of unequal divisions. Moreover, scalene triangles lack strong visual regularity, making them more difficult to construct as mental images. Unlike isosceles or equilateral triangles, which appear symmetrical and "neat," scalene triangles are considered unfamiliar, visually unstable, and harder to recognize as general representations of triangles.

Additionally, prior learning experiences in school more frequently presented prototypical, symmetrical triangle examples, leading students to associate the concept of a triangle with shapes having balanced sides or angles. As a result, when asked to draw a triangle spontaneously, students tend to rely on the most easily visualized shapes, rather than scalene triangles, which require greater spatial flexibility and a more formal conceptual understanding.

Right Triangle

Under the same task condition, which required dividing the right triangle into four equal parts, Figure 2 above illustrates that the right triangle can be divided into four equal parts as shown in the figure.



(a) (b)

(c)

Figure 2. Students' Responses to Isosceles Triangles

Pengertian segitiga siku-siku *yaitu segitiga yang salah satu sudutnya membentuk sudut 90 derajat. Sisi yang berhadapan dengan sidut siku-siku disebut hipotenusa, dan dua sisi lainnya disebut sisi-sisi siku-siku.*

Analysis Results: Based on the definition of a right-angled triangle, the closest representations are shown in Figures 2(a), 2(b), and 2(c), each containing a right angle. However, Figures 2(a) and 2(b) lack explicit right-angle markers. In Figure 2(a), the student drew a right-angled triangle and divided it into four parts by bisecting each side into two equal segments and drawing lines connecting these points, so that three lines intersected and divided the large triangle into four smaller triangles. Although the resulting shapes are similar, the areas of these smaller triangles are not equal. Specifically, the two triangles adjacent to the hypotenuse have larger areas than the other two. In Figure 2(b), the student also drew a right-angled triangle and attempted to divide it into four parts. However, the resulting triangles were not equal in area; only two pairs of small triangles were equal. In Figure 2(c), the student divided the right angle at vertex A into four equal angles, drawing lines from these points to the hypotenuse to divide the large triangle into four smaller triangles. Although the

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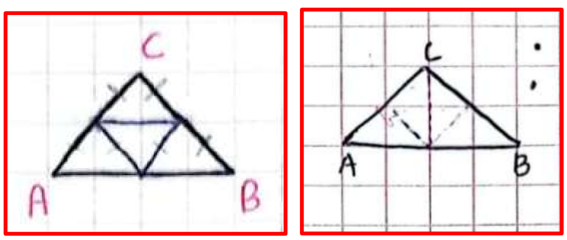
angles at vertex A are equal, this method does not guarantee equal areas for the four triangles. This is because the dividing lines do not partition the hypotenuse into equal segments, and the lengths of the sides of the resulting triangles are proportional to the lengths of the lines drawn from the vertex to the hypotenuse. Consequently, the four triangles have different areas.

Isosceles Triangles

Based on Figure 3 above, students indicated that the isosceles triangle can be divided into four equal parts as shown in the figure.

Pengertian Segitiga Sama Kaki *adalah bangun datar beerbentuk segitiga yang memiliki 2 sisi sama panjang atau dua sudutya sama besar.*



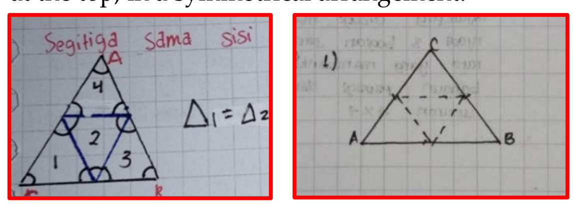
(a) (b)

Figure 3. Students' Responses to Isosceles Triangles

Analysis Results: In Figure 3(a), when a student drew an isosceles triangle and attempted to divide it into four equal parts by bisecting each side and drawing lines from the division points, the resulting four triangles were not equal in area. The differences in area arise from the unequal lengths of the initial sides and the asymmetrical partitioning of the base (AB), which caused some of the smaller triangles to have different side lengths and therefore unequal areas. The figure below illustrates a student's attempt to construct an isosceles triangle. Similarly, in Figure 3(b), another student drew an isosceles triangle and divided it into four parts. Again, the resulting triangles were not equal in area, with only two pairs of smaller triangles being equal.

Equilateral Triangle

Among the students, 11 drew equilateral triangles in Question 1, while 6 students drew equilateral triangles in Question 2 following the same instructions. For isosceles triangles, 13 students drew them in Question 1, and 5 students in Question 2. Additionally, 3 students drew right-angled triangles in Question 1, whereas 16 students drew right-angled triangles in Question 2. The preference for equilateral and isosceles triangles can be attributed to students' prior experiences. Since elementary school, students are often exposed to triangles in "symmetrical" forms, resulting in the strongest mental images being upright and balanced triangles. Such representations are visually secure and easily recognizable. Most mathematics textbooks and teachers employ standard triangle examples, typically with the base at the bottom and the apex at the top, in a symmetrical arrangement.



(a) (b)

Figure 4. Students' Responses to the Equilateral Triangle

From the figure above, students indicated that the equilateral triangle can be divided into four equal parts, as illustrated in Figure 4.

Pengertian segitiga sama sisi *adalah bangun datar berbentuk segitiga yang memiliki 3 sisi sama panjang atau ketiga sudutnya sama besar 60 derajat.*

Analysis Results: Based on the definition of an equilateral triangle, the closest representation is shown in Figure 4(b), where all sides are of equal length. Figure 4(a) requires slight adjustments in measurements, as it actually depicts an isosceles triangle rather than an equilateral triangle. If an equilateral triangle is divided into four parts, the division will be accurate only if the lines are drawn at the midpoints of the three sides, approximately as illustrated in the figure above. Both figures serve as examples of division into equal parts, where the partitions are drawn precisely at the midpoints. From Figure 4(a), it can be observed that the resulting parts would not be equal in area, which is why Figure 4(a) is less accurate to be considered an equilateral triangle.

The Relationship Between Mental Models and Triangle Drawing

The relationship between mental models and triangle drawing can be explained through the activation of cognitive schemata that students possess when constructing geometric representations in their minds. When students are asked to draw a triangle, they do not merely recall the formal definition of a triangle, but also activate schemata formed from prior learning experiences, frequently encountered visual examples, and shape patterns stored in long-term memory. These active schemata then influence the emerging mental models, which explains why many students tend to draw right-angled triangles, as these shapes are the most familiar and easily visualized. From a schema theory perspective, knowledge that is frequently used is more easily retrieved and serves as the basis for visual decision-making. Therefore, the triangles drawn by students reflect how mental models and active schemata work together in the process of understanding and representing geometric concepts. Based on the analysis of various triangle drawings produced by prospective mathematics teachers, the following patterns emerge:

1. Standard Representations in the Mind: When asked to draw a triangle, students tend to draw right-angled, symmetrical, and easily recognizable triangles, such as right-angled, equilateral, or isosceles triangles. This is because these shapes are frequently taught and used in education, becoming “standard” representations in their minds.
2. Tendency to Choose Familiar Shapes: Students select shapes that are more familiar and perceived as “easier” or more correct, such as right-angled, equilateral, or isosceles triangles, because they are more orderly and well-known.
3. Avoidance of Ambiguity: Drawing a scalene triangle, with unequal sides and asymmetrical angles, may create uncertainty about whether the shape is indeed a triangle. A clear mental image reduces such ambiguity.
4. Cognitive Process: The brain tends to seek representations that are most accessible and frequently used. Symmetrical triangles are easier to visualize and draw.

The analysis of triangle drawings produced by prospective mathematics teachers indicates that their geometric representations are strongly influenced by prototypical mental images. Students tended to draw standard and familiar forms, such as right-angled, equilateral, and isosceles triangles, rather than irregular forms such as scalene triangles. This tendency reflects the role of prototype theory in geometric thinking, where learners rely on frequently encountered and instructionally reinforced examples stored in long-term memory as cognitive shortcuts during problem-solving (Fischbein, 1993; Hershkowitz et al., 2002). Familiar and symmetrical figures are perceived as easier, more orderly, and more legitimate representations of triangles, thereby reducing uncertainty during drawing tasks.

The limited use of scalene triangles suggests the presence of prototype bias and a possible gap between formal geometric definitions and students’ mental images. Although scalene triangles are mathematically valid, their asymmetrical and irregular structure may not align with students’ dominant image of what a triangle “should” look like, leading to avoidance or hesitation in representation. This finding is consistent with studies showing that students often prioritize visually accessible, symmetrical, and easily manipulated figures in geometric reasoning (Vinner, 1991; Kozhevnikov et al., 2002). Overall, the findings indicate that prospective mathematics teachers’ geometric representations are shaped by cognitive economy, instructional exposure, and the accessibility of mental images, which influence how they construct and apply geometric understanding.

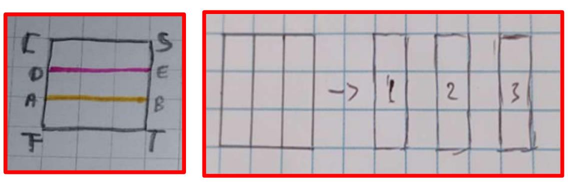
Rectangles and Squares

In the subsequent task, Question 3, students were asked to draw a quadrilateral, assign it a name, and divide it into three equal parts. From this task, 22 students drew a rectangle, 20 students drew a square, and 9 students drew a trapezoid. Additionally, 2 students drew a parallelogram, and 1 student drew a kite-shaped quadrilateral. The complete results of students' responses can be seen in Table 2 below.

Table 2. Students' Responses Regarding Quadrilateral Models

Quadrilateral Name	Number of Quadrilateral Models		Jumlah
	1	2	
Rectangle	8	14	**22**
Square	17	3	**20**
Trapezoid	2	7	**9**
Rhombus	0	0	**0**
Parallelogram	0	2	**2**
Kite	0	1	**1**
Total Students	**27**	**27**	**54**

The preference for rectangles and squares can be attributed to students' frequent exposure to such shapes in daily life, including blackboards, books, tablecloths, desks, phone screens, and doors. This constant visual exposure reinforces the mental image of squares and rectangles, making them the most readily accessible and familiar quadrilaterals for students.



(a) (b)

Figure 5. Students' Responses to the Square

Based on Figures 5(a) and 5(b) above, students stated that a square can be divided into three equal parts, as illustrated in the figures.

Pengertian Persegi *adalah bangun datar dua dimensi yang memiliki empat sisi yang sama panjang dan empat sudut yang semuanya siku-siku (90 derajat).*

Analysis Results: Based on the definition of a square, both figures accurately represent the shape. To divide the square into three equal parts, Figure 5(a) uses a horizontal division, whereas Figure 5(b) uses a vertical division. Among all students who drew a square in Question 3, the square was divided exclusively in these two ways, either vertically or horizontally.

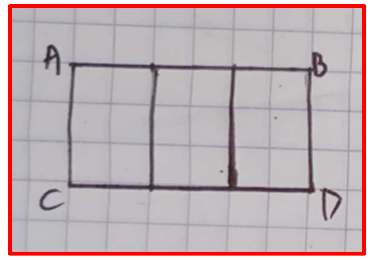


Figure 6. Students' Responses to the Rectangle

Based on the figure above, students stated that a rectangle can be divided into three equal parts, as illustrated in the figure.

Pengertian Persegi Panjang *adalah bangun datar dua dimensi yang memiliki empat sisi, di mana sisi-sisi yang berlawanan memiliki panjang yang sama. Keempat sudut dalam persegi panjang adalah sudut siku-siku (90 derajat).*

Analysis Results: Based on the definition of a rectangle, both representative figures accurately depict the shape. To divide the rectangle into three equal parts, Figure 6(a) uses a vertical division. Mentally, rectangles are often represented as shapes with a horizontal orientation and clearly defined left and right sides, making vertical divisions appear simpler, more orderly, and symmetrical compared to horizontal or diagonal divisions. Additionally, everyday experiences with objects such as windows, doors, tables, and columns reinforce the mental model that rectangles are more commonly partitioned into vertical segments, consistent with the visual representations stored in students' memory.

Trapezoid

Based on the figure above, students stated that a trapezoid can be divided into three equal parts, as illustrated in the figure.

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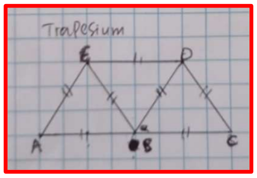
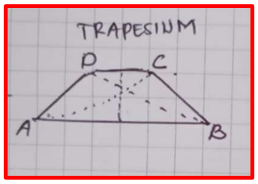
Pengertian trapesium *adalah bangun datar dua dimensi yang memiliki empat sisi (segi empat) dengan satu pasang sisi yang sejajar.*





(a) (b)

Figure 7. Students' Responses to the Trapezoid

Analysis Results: Based on the definition of a trapezoid, both representative figures accurately depict the shape. To divide it into three equal parts, Figure 7(a) shows lines drawn from vertices E and D to point B, resulting in equal sections. Among all student responses that drew a trapezoid and divided it into three equal parts, the method illustrated in Figure 7(a) represents the standard approach. In contrast, Figure 7(b) divides the trapezoid into six unequal parts, failing to follow the instructions provided in the task.

Parallelogram

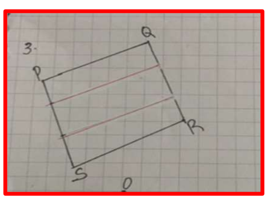


Figure 8. Students' Responses to the Parallelogram

Based on Figure 8 above, students stated that a parallelogram can be divided into three equal parts, as illustrated in the figure.

Pengertian jajargenjang *adalah bangun datar dua dimensi yang memiliki empat sisi, di mana setiap pasangan sisi yang berlawanan sejajar dan memiliki panjang yang sama.*

Analysis Results: Based on the definition of a parallelogram, Figure 8 accurately depicts a parallelogram with opposite sides parallel and of equal length. To divide the parallelogram into three equal parts, students divided it vertically. However, it is unclear whether the three parts are truly equal in area, since dividing a parallelogram into three equal parts requires the use of altitudes. In the figure, students did not indicate or construct the altitudes of the parallelogram. In Question 4, 14 students drew a rectangle, 3 students drew a square, 7 students drew a trapezoid, 2 students drew a parallelogram, and 1 student drew a kite-shaped quadrilateral.

Kite

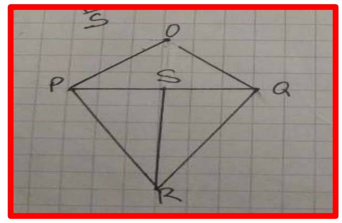


Figure 8. Students' Responses to the Kite

Pengertian layang-layang *adalah bangun datar (bangun berdimensi dua) yang dibentuk oleh dua pasang sisi yang masing-masing pasangannya sama panjang dan saling membentuk sudut dengan besaran sudut yang saling berhadapan sama besar.*

Analysis Results: Based on the definition of a kite-shaped quadrilateral, Figure 8 accurately depicts a kite with two pairs of adjacent sides of equal length and opposite angles (∠P and ∠Q) that are congruent. Students did not provide a name for the quadrilateral they drew. To divide the kite into three equal parts, students attempted both vertical and horizontal divisions. For the horizontal division, students drew a line from vertex P to vertex Q, forming an isosceles triangle. They then marked the midpoint of the line PQ as point S and drew a vertical line from S to point R, creating two right triangles. This process resulted in the three subdivided regions not being equal in area. From the analysis of the various quadrilateral drawings by prospective mathematics teachers, several patterns emerged:

(1) Visual and Cognitive Simplicity: When asked to draw quadrilaterals, students often divided the shapes vertically or horizontally because this method is the simplest and most intuitive. The brain tends to select the most visually accessible solution.

(2) Symmetry and Order: Symmetrical shapes like squares, when divided vertically or

horizontally, maintain visual balance, which is preferred cognitively. Symmetry is important as it creates regular and easily recognizable patterns.

(3) Prior Experience and Learning: Common quadrilateral division patterns taught from an early age in mathematics or art encourage students to choose vertical or horizontal divisions.

(4) Mental Image and Prototype: Vertical and horizontal divisions of quadrilaterals have become familiar visual prototypes in students' minds, making them the default approach when asked to subdivide shapes.

(5) Clarity and Ease of Execution: Vertical or horizontal divisions produce clear results and are easy to perform, avoiding ambiguity in the subdivided parts.

(6) Habits in Graphical Representation: Frequent use of vertical and horizontal divisions in graphical representations reinforces students' visual habits in dividing quadrilaterals.

The analysis of quadrilateral drawing tasks reveals that prospective mathematics teachers predominantly rely on visually simple, symmetrical, and cognitively efficient strategies, particularly vertical and horizontal partitioning. This preference reflects the influence of cognitive load constraints, where learners tend to minimize working memory demands by selecting the most straightforward and familiar visual-spatial operations (Sweller, 2018; Mayer, 2021). Symmetrical structures such as rectangles and squares are perceived as more stable and easier to process mentally, thereby reducing ambiguity during representation and partitioning tasks. This finding is consistent with research emphasizing that self-generated visual strategies significantly enhance mathematical problem-solving efficiency, as visual representations are processed more rapidly and with lower cognitive effort than abstract symbolic reasoning (Zhang & Lin, 2020; OECD, 2021).

Furthermore, the dominance of vertical-horizontal partitioning is strongly shaped by prior instructional exposure and the formation of cognitive schemas through repeated learning experiences. Studies in mathematics education indicate that repeated engagement with canonical representations leads to the development of automated schemas and prototype-based reasoning, which learners subsequently apply as default strategies in novel tasks (Star & Rittle-Johnson, 2019; Lithner, 2020). As a result, students tend to reproduce familiar geometric patterns rather than exploring alternative decomposition strategies, demonstrating the influence of instructional reinforcement on mental model formation. This reliance on entrenched visual prototypes highlights the interaction between perceptual fluency, memory structures, and educational experience in shaping how learners construct and manipulate geometric representations.

Conclusion

This study indicates that prospective mathematics teachers still predominantly rely on prototypical mental models in representing geometric shapes. The representations produced tend to follow the most frequently taught and easily visualized forms, such as right, isosceles, and equilateral triangles, as well as squares and rectangles. In addition, the problem-solving strategies employed are largely characterized by simple approaches, particularly vertical and horizontal partitioning, which reflect a preference for cognitively less demanding solutions. These findings suggest that students' geometric thinking is still strongly influenced by prior learning experiences and has not yet fully developed toward a flexible and formal conceptual understanding. Furthermore, the results reveal that the development of mental models in geometry remains suboptimal due to limitations in constructing non-prototypical representations, such as scalene triangles or more complex geometric decompositions. This condition highlights the need for innovative instructional approaches in geometry education that emphasize diverse visual representations, strengthen spatial reasoning skills, and reduce over-reliance on prototypical examples. Consequently, geometry learning in higher education should be directed toward enhancing students' flexibility in mental modeling to support more formal and creative problem-solving abilities.

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