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Mathematical Reasoning Abilityin Geometry Learning Based on A Realistic Approach Assisted by AI for Students of hhe Mathematics Education Study Program in State University of Medan

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ABSTRACT

This study aims to improve students' mathematical reasoning abilities in geometry learning that integrates a realistic approach with an *Artificial Intelligence* (AI) platform. This research was conducted at the Mathematics Education Study Program, Department of Mathematics, Faculty of Mathematics and Natural Sciences, Medan State University in the odd semester of the 2025/2026 academic year with a design research model by Freudenthal. The subjects of the study were 26 students from the PSPM class of 2024 and 25 students from the MESP class of 2024 taken by purposive sampling. The learning process was carried out in 12 meetings with 4 tests. The results showed that the mathematical reasoning ability of PSPM class students reached an average of 75.2 with a classical completeness of 92%. Meanwhile, the mathematical reasoning ability of MESP class students reached an average of 87.0 with a classical completeness of 100%. Thus, geometry learning based on a realistic approach assisted by AI can improve students' mathematical reasoning abilities and can strengthen the mathematical proof and argumentation abilities of students in the Mathematics Education study program, Medan State University.

Keywords: Realistic approach, Mathematics, Reasoning, Geometry, AI.

INTRODUCTION

Reasoning is a higher-order thinking skill that enables students to analyze, generalize, prove, and justify ideas. In mathematics learning, reasoning plays a central role in understanding concepts deeply, building connections between concepts, and developing problem-solving skills that can be transferred to other contexts (Akker, J. Van den. 1999; Alderton, J., & Pratt, N. 2025). Detailed mathematical reasoning skills can help students understand higher mathematical skills, including proof, problem solving, critical thinking (Asoraya MS. & Redo Martila Ruli. 2023; Astiati, SD 2020), and support analytical thinking that is useful in science, technology, programming, and data-based decision making (Ausubel, DP 2000; Battista, MT 2022). In mathematics learning, reasoning is a core skill needed by mathematics students to solve problems, build arguments, formulate theorems, verify assumptions, and communicate abstract ideas logically (Fauzan MF, et.al. 2022). Students who have high reasoning skills will be able to solve problems well (Frudenthal, H. 2002). However, various studies have shown that students' mathematical reasoning skills are still inadequate,particularly in the areas of transferring knowledge to new contexts and constructing systematic proofs. This is particularly evident in geometry learning, where students often struggle to understand the relationships between theorems, prove the properties of shapes, and connect visual representations with deductive arguments. Meaningful learning theory suggests that conceptual understanding will be more robust if it is linked to existing cognitive structures (Gravemeijer K. 1994). Therefore, geometry learning must connect real objects with abstract structures to be meaningful.

Geometry is a compulsory basic course that must be taken by students in the Mathematics Education Study Program, Faculty of Mathematics and Natural Sciences, Medan State University with a weight of 3 credits, in addition to advanced courses in Analytical Geometry and Euclidean and Non-Euclidean Geometry. Geometry is a branch of mathematics that plays an important role in the development of students' logical, spatial, and deductive reasoning abilities, and is studied at every school level (Hamna, et.al. 2025). In the context of mathematics education in higher education, mastery of geometry is a crucial foundation for prospective mathematics educators in understanding and mastering mathematical concepts conceptually and contextually (Hasratuddin, et.al. 2022). Several research results show that students still experience difficulties in understanding basic geometric concepts, especially in relating geometric objects to real contexts (Hasratuddin. 2020), so they have difficulty in compiling proofs (Hidayat, A. et.al. 2022; Hwang, GJ, Xie, H., Wah, BW, & Gašević, D. 2020). Difficulties in learning geometry occur due to a lack of contextual learning experiences and adequate *scaffolding support (Joachin-Arizmendi, I. 2024; Kappassova, S. 2025).*

One relevant action to address this challenge is implementing a Realistic approach-based learning assisted by *Artificial Intelligence* (AI). The realistic approach is one approach in *Realistic Mathematics Education* (RME) learning that was originally developed in the Netherlands by Freudenthal in 1980 (Lathiful Anwar, et.al. 2021). In this approach, geometry learning does not only focus on symbols or formal definitions, but starts from contextual problems that are realistic and close to the students' experiences, then solves them individually or in interactive groups, ultimately finding solutions or mathematical concepts. In short, students can construct geometric concepts through experience and initial understanding of geometry in a gradual and meaningful manner (Mohammad, et.al. 2018). The use of RME in geometry teaching can also improve conceptual understanding and problem-solving abilities (Nieveen, N. 1999; Nurhaolida, et.al. 2022). In addition, several recent studies and systematic reviews have found that: (1) contextual task-based interventions and quantitative modeling can improve the quality of students' mathematical reasoning by enriching their ability to formulate assumptions, derive hypotheses, and construct mathematical reasoning (Olteanu, C. 2022) ; (2) training that combines evidence-oriented discussions, group work, and real-life modeling tasks results in the transfer of reasoning to new tasks; and (3) although much of the positive evidence comes from secondary school research and instructional materials development, university-level literature also shows a trend of increasing mathematical reasoning and argumentation abilities after the implementation of a realistic approach with 3 principles (1) *Guided reinvention / progressive mathematizing* (guided discovery) *,* (2) *Didactical phenomenology,* and (3) S *elf-developed model*); and 5 characteristics (1) *constructing* and *concretizing,* (2) *levels* and *models* , (3) *reflection and special assignment,* (4) *social context* and *interaction, and* (5) *structuring* and *intertwining*) ; as well as 2 doing math (*horizontal and vertical mathematization*) (Pendy A., and Hilaria Melania Mbagho. 2021; Piaget. 1970. Piaget, Jean. 1970).

In addition to a realistic approach, the integration of artificial intelligence (AI) technology is an innovative strategy for creating a more personalized, adaptive, and interactive learning experience. AI enables dynamic visualization of geometric shapes, automatic feedback, and real-time identification of student learning difficulties (Sarumaha Antonius, 2021; Simatupang, Simeon A., et al., 2024). This is particularly helpful in teaching geometry, which demands visualization and spatial representation skills.

Based on the description, this study aims to design and test geometry learning based on a realistic approach assisted by AI to improve the mathematical reasoning skills of students in the Mathematics Education Study Program, Department of Mathematics, State University of Medan. It is hoped that this innovation can be a real contribution to improving mathematical reasoning skills and the quality of contextual, humanistic, and technology-assisted geometry learning.

RESEARCH METHODS

This type of research is a design research with three stages: *front-end analysis,* prototype, and assessment (Somuncu, B., et al. 2021; Suryanto, et.al. 2021). The research location was carried out in the Mathematics Education study program, Department of Mathematics, Faculty of Mathematics and Natural Sciences, State University of Medan. The subjects of this study were 26 students of PSPM 2024 and 25 students of MESP 24. This research was conducted in the same time block with each class conducting 12 face-to-face lessons and 4 tests. The geometry learning implemented in this study used a realistic approach assisted by AI. The learning implementation was carried out using the Freudenthal version of the cyclical process design (Treffers, A. 1993) as follows.

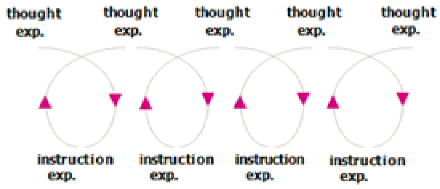


Figure 1. Design research cycle process, Freudenthal, 2002.

Figure 1 above shows that the research procedure starts from thinking about or planning improvements to learning and then implementing them, then evaluating the results and thinking about improvements and implementing learning, and so on until learning is effective for students' mathematical reasoning abilities.

RESEARCH RESULT

This research was carried out on mathematics education study program students, mathematics majors entering 2024 in the PSPM and MESP classes. The PSPM class is the first study of each teaching material topic, while the MESP class is the second study of each learning material topic that is the same as the PSPM class. This is done because the PSPM and MESP classes are learning blocks of the same time, namely block I of the two time blocks determined by the mathematics department. The learning implementation in each block is 16 times over 8 weeks. In this way, learning meetings for each class per week can be held 2 times. Because the learning meeting in the PSPM class is scheduled to be held earlier than the MESP class, the learning of each new topic material is carried out in the PSPM class, and the MESP class is the second learning for each topic of the same material. In this way, the MESP class is an implementation of remedial learning from the learning carried out after the PSPM class for each teaching material topic.

Implementation of learning.

1. Lesson 1.

First meeting. After the lecturer gave an apperception, the lecturer gave the students a problem in the form of a challenge, namely;

What is mathematics and why should we study mathematics?

The aim of solving this problem is:

a. Providing motivation while instilling mathematical values.
b. Students can understand that geometry is axiomatic deductive.
c. Students can understand that mathematical truth is hierarchical and rational.

Student responses included:

- Mathematics is related to numbers.
- Mathematics is a tool for calculating +, x, : and -.
- Mathematics is an exact science.
- Mathematics is problem solving.
- And others like that

The trajectory of the teaching and learning process: D (Lecturer), M (Students).

D=: ask students to answer orally the question, what is mathematics?

M=: 65% of students said that mathematics is the science of counting which is related to numbers, 15% of students said that mathematics is solving problems, 12% is an exact science, and 8% said that mathematics is a science.

D:= Mathematics is not just about counting, pay attention to the following two statements; 1) Good goods are not cheap, 2) Cheap goods are not good. Who can prove whether these two statements are the same or different? The answer is mathematicians, namely by using logic. So, clearly, these two statements do not have numbers, mathematicians can prove them rationally.

Furthermore,

D=: conveying the nature and purpose of learning mathematics, al. 1) understanding that he has limitations. This means that students are allowed to make mistakes, not the smartest, not the greatest, often make mistakes. The consequences are that a) learning mathematics can be wrong, giving birth to attitudes 3) changing for the better, moving on, today must be better than yesterday, 2) being able to choose what is good and right, 4) giving birth to a skeptical attitude, not easily believing, so that he will do what he knows, and not do what he does not know, if he wants to know he will ask those who know more, 5) giving birth to an attitude of never giving up (*never give up*).

Reflection on problem solving:

a. Students do not have the confidence to state what they know about mathematics.

Students are beginning to develop a mathematical identity. This is evident in their increasing confidence in critical and rational thinking, a growing sense of self, as if they must be able to do things differently from others, creatively and critically, and a relentless spirit.

2. **Learning k- 2 and 3.** Rectangle Problems

a) Problem: The length of the perimeter of a rectangular garden plot is 24 m. Question: What are the dimensions of the rectangular garden so that it has the largest area?

b) Learning objectives: Students can understand the elements, definitions and concepts of points, rays, lines and planes of rectangles, squares, triangles and polygons.

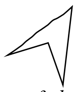
c) Individual student responses included: 48% of students answered (9x7) m, 35% answered (8x8) m (answered with derivative, wrong), and 17% were unsure whether a square was a rectangle.

d) Learning trajectory;

D : The lecturer gave the students a challenge, draw a quadrilateral, so what is a quadrilateral?

M: which has 4 sides and 4 corners.

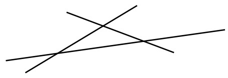
D:= how about this?



M:= other students responded that the sum of the angles was 360 º .

D:= what is that, the angle is not 360 º ?

D := giving *scapolding* or *hint*. Try to pay attention, I will draw a triangle! Like this. *Can* you show which one is a triangle? Then, why aren't the others triangles? After the lecturer had constructed triangles and quadrilaterals four times, the students were finally able to say,



M:= a triangle is a closed flat plane constructed by 3 lines.

A quadrilateral is a closed flat surface constructed by 4 lines.

Furthermore, students can understand lines, rays and segments and can state the definition of polygons.

The lecturer directs students to return to the problem of 'what is the size of a rectangle with a perimeter of 24 m that has the largest area?' By facilitating the learning process through students' initial abilities, the lecturer derives the definition of a quadrilateral, parallelogram, and trapezium, namely by paying attention to parallel sides. Then the lecturer derives the definition from a parallelogram to a rectangle and a rhombus.

Finally, the definition of a square is derived from a rectangle. Thus, students can conclude that *a square is a rectangle*. Thus, with confidence and pride, students can state that the dimensions of a rectangle with a perimeter of 24 m and a maximum area of 6 m are 6 m long and 6 m wide.

e) Reflection:

Students can understand the concepts of lines, rays, segments, triangles, and quadrilaterals, and so on. By understanding the definition/concept of a quadrilateral, through creative thinking skills, students can name triangles, pentagons, and so on up to infinite sides, namely circles. Problem 2 can certainly improve reasoning skills. Students' enthusiasm and confidence are boosted by discovering the concept that a square is a rectangle.

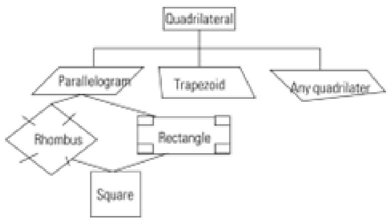


Figure 2.

3. 4th meeting. Test I was conducted:

Reasoning Problem **:** If there are isosceles, equilateral, right-angled triangles and any triangle has the same perimeter, then which triangle has the largest area? Give reasons for your answer.

The results of the mathematical reasoning ability test for students in the first phase of the PSPM class reached an average of 48.2 with a classical completion rate of 0%. Meanwhile, the results of the mathematical reasoning ability test for students in the MESP class reached an average of 59.6 with a classical completion rate of 20%. These results indicate that the target of mathematical reasoning ability expected from geometry learning based on a realistic approach assisted by AI has not been achieved for both classes, namely a minimum of 85%. Thus, improvements to the learning process that will be carried out are still needed. From the results of the analysis of students' problem answers, it can be seen that the factors causing the failure to achieve the target through geometry learning include, among others, it is suspected that 1) the learning process used in the first trial in 3 meetings was individual, and students were less focused in solving the problems given, and through AI did not provide rational solutions, and 2) the problems given in the learning process were not understood enough to be solved. Therefore, the learning process based on a realistic approach will be improved in the next stage by providing a display of problems accompanied by images and the formation of study groups (Treffers, A. 1987) .

4. Meeting 5: Problem of dividing triangular inherited land

a. Problem: Mr. Somat has a triangular piece of land, which he divided among his three sons by dividing one side of the land into three equal parts, then at the dividing point he drew a line from the corner in front of him. The question is, is it fair for Mr. Somat to divide it in that way?

b. Learning objectives: students are expected to;
- can understand the concept of the height of a triangle.
- improve students' mathematical reasoning abilities.

c. Student response;
- 60% of students said it was unfair,
- 28% did not respond, and
- 12% answered fairly by giving reasons that were not mathematical.

d. Learning trajectory:

When students say that the three triangles do not have the same area, it is suspected that the causal factor is;
- Students in the group cannot determine the height of the triangle.
- Cannot think rationally looking at the problem given.
- Students lack curiosity.

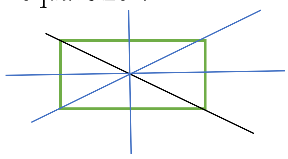
Next, the lecturer asked the students to draw a triangle. Then, with the definition of altitude (a line perpendicular to the base of the triangle's peak), the students were asked to draw the altitude of the triangle by replacing each side of the triangle with the base. By asking a student to draw a triangle on *the whiteboard* , and together the students provided assistance to draw three altitude lines of the triangle. In this way, the students discovered the concept of the altitude of the triangle, which has 3 altitude lines. After that, the lecturer asked to draw a triangle about the problem of dividing Mr. Somat's land in the form of a triangle which will be divided by his 3 children, is the division method fair? With the help of the altitude drawing on each part of the triangle, the students were able to find the answer to the problem, and concluded that Mr. Somat was a fair person in dividing the land, because it had the same area.

e. Reflection revealed that the students didn't immediately find the answer to the problem because they hadn't provided a correct and precise triangle drawing for Mr. Somat's land that would be distributed. By drawing the altitude of the triangle themselves, they would have felt that mathematics is a process.

The learning process in the MESP class is carried out by providing the same problems as in the PSPM class, only supplemented with a picture of Mr. Somat's land and problems on the worksheet in the form of a conflict (Van den Heuvel-Panhuizen, M., & Drijvers, P. 2020) in the form of a triangle assisted by the Geometry Expression program *,* according to the realistic approach stages with a group discussion model with 6-7 members each.

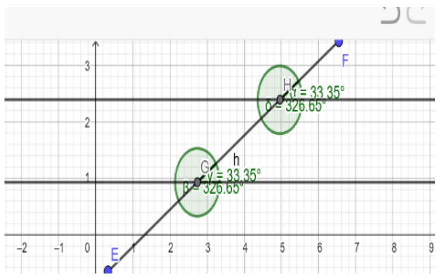
5. 6th learning process;

a) The problem given is “Determine the number of ways to divide 2 rectangles of equal size”.



- Objective of the problem: To improve students' reasoning and creative thinking abilities as well as students' emotional intelligence.
- Student responses: 4 ways, wrong (68%); 2 ways, wrong (12%); Infinite, correct (5%); and No response, unsure and don't know (15%).
- Reflection: Students still think linearly, lacking reasoning or creativity.

b) Problem 1; What do you know about “if a straight line intersects two straight lines and makes the interior angles on one side less than twice the right angle, the two lines if extended indefinitely, will meet on the side where the interior angles on one side are less than twice the right angle.

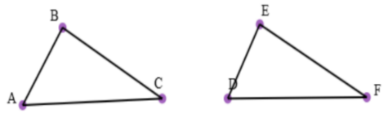


- Objective of the problem: Students can understand the concept of parallelism in Euclid's geometry.
- Student response and learning trajectory. Together with the lecturer, students draw 2 lines and are cut by a transversal line with the help of Geogebra. Through the picture, students understand that if the angle $(H_1 + G_1) < 180^o$, the lines intersect to the right of the angle, if the angle $(H_1 + G_1) > 180^o$, the lines intersect to the left of the angle and if the angle $(H_1 + G_1) = 180^o$, then the lines do not intersect Everywhere or are called parallel lines.

Next, a problem about congruence is given, with the learning process as follows.

c) Problem: If two triangles have two sides and the included angle equal, then their third side is equal? Give a reason for your answer.

- Objective of the problem: Students can understand the concept of congruence while simultaneously improving their reasoning and creative thinking abilities and improving students' emotional intelligence.
- Student response; 78% of students believe that the properties (ss, sd, ss) are congruent, but cannot provide valid reasons as evidence.
- Learning trajectory; The lecturer reminds students about the definition of congruence, namely that several shapes are said to be congruent if they occupy each other's frame when pressed together. In other words, congruent means the same and similar. Then, the lecturer describes two triangles ABC and DEF which have the same properties ss, sd, ss. Then, by contradiction, together with students, they show that the properties ss, sd, ss in triangles fulfill the congruence property.



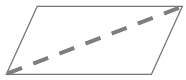
- Reflection: The students' weakness in this case is that they do not fully understand the definition of congruence, the concept of similarity, and logical proof. Therefore, the lecturer facilitates learning to understand the properties of congruence through proofs of contradictions.

6. Learning process Meeting 7.

Students are given challenges, namely;

a) Problem; Prove that the pairs of sides of a parallelogram are equal.

- Objective of the problem: Students can use the concept of congruence and understand that the length of a pair of sides of a parallelogram is a concept, not a definition.
- Student response: In discussion, initially students were unable to connect what they knew with what they were asked.
- Learning trajectory. The lecturer reminds students about the definition of a parallelogram and asks them to draw a parallelogram. Through this scaffolding , students can work on solving problems by linking the definition and the concept of congruence.



- Reflection: Students do not understand the meaning and use definitions and concepts for new problems.
- action ; need to provide lots of practice.

b) Problem 2; Prove that the sum of the angles in a triangle is 180^{o} .

- Objective of the problem: Students can understand that the sum of the angles of a triangle in Euclidean geometry is 180 o .
- Student response. Students demonstrate this by attaching opposite angles and then using the definition of supplementary angles. Students are unable to state that the angles they attach are interior alternate angles.
- Reflection and Further Action. Students need to understand the definitions and initial concepts that have been proven. Students need to be given exercises.

c) Question 3; Do you know and believe that, "The exterior angle of a triangle is greater than the interior angle that is not adjacent to the exterior angle?"

- Objective of the problem: Students can understand that the concept of the exterior angle of a triangle is greater than the interior angle that is not adjacent to it.
- Student response. Students have difficulty showing the exterior angles of triangles.
- Learning trajectory. The lecturer asks students to draw a closed triangle formed by three lines. From the resulting drawing, together with the lecturer, students can identify the exterior angles of the triangle. Furthermore, students can demonstrate that the exterior angle of a triangle is larger than the interior angle that is not adjacent to it.
- Reflection: It is suspected that students do not describe the problem appropriately and still use shortcuts that are deemed appropriate, such as just using formulas.

7. 8th meeting. Implementation of Phase II Test .

Reasoning Problem . Prove that the angle opposite the exposed side of a triangle is the largest.

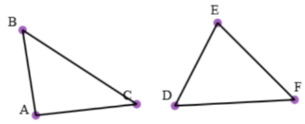
The results of the mathematical reasoning ability test for PSPM class students reached an average of 63.2 with a classical completion of 50%. Meanwhile, the results of the second trial for the MESP development class reached an average of 66.0 with a classical completion of 68%. These results indicate that the expected ability target through AI-assisted realistic approach-based geometry learning has not been achieved in both classes, namely at least 85%, although there has been an increase. Thus, learning improvements still need to be made.

From the results of the analysis of student problem answers, it can be seen that the factors causing the failure to achieve learning targets include, among others, suspected to be due to 1) the learning process used in the second phase of the trial for the PSPM class was ineffective in groups of 6-7 people. Because there were too many and not all group members were actively providing ideas for problem solutions. Therefore, discussion groups in the next learning process will be made into more effective learning groups.

8. Lesson 9.

a) Problem; What do you know about ' If the angles of a triangle are congruent to the angles of another triangle then the two triangles are similar.

- Objective of the problem: Students can understand the concept of similarity.
- Student response; Students draw 2 triangles.



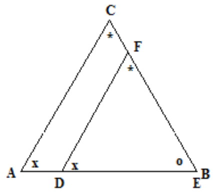
Then, write;$\angle A = \angle D$

$\angle B = \angle E$

$\angle C = \angle F$

Then, the student cannot continue.

- Reflection: It is suspected that the causal factor is that the students have not described it accurately, only correctly.
- trajectory :



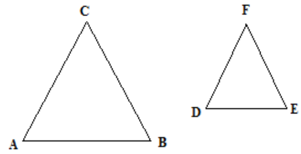
1) The lecturer asked students to understand the problem and illustrate it with pictures.
2) Then the students describe it correctly and precisely.

- Then, the lecturer asked students to describe their understanding of the image of two triangles, namely ΔABC and ΔDEF.
- Then the students write as follows;

$\angle A = \angle D$

$\angle B = \angle E$

$\angle C = \angle F$

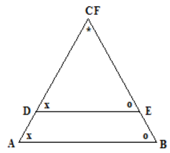


- Then, the lecturer asked what the problem bill was?
- Students answer by writing down their bills; prove it: $\Delta ABC \sim \Delta DEF$?
- Then, the lecturer asked the students to put the two pictures together and write down the consequences.
- Students describe and write what the consequences are, as follows;

$\angle C = \angle F$ (*crowded*)

$\angle A = \angle D$ (*facing*)

$\angle B = \angle E$ (*facing*)



- Lecturer, what can you conclude?
- Students, because there are two angles that are congruent and opposite, then AB ∥DE.

Analogy, BC ∥EF and AC∥. Thus students can conclude.

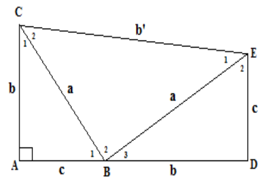
So, $\frac{AB}{DE}=\frac{BC}{EF}=\frac{AC}{DF}$, according to the definition of similarity, it is proven that $\Delta ABC \sim \Delta DEF$. *Qed.*

Conclusion: *If the corresponding sides of two proportional triangles are similar.*

- Reflection: in subsequent learning, it is necessary to emphasize that mathematics needs to concretize imagination by describing it correctly and precisely.

9. Lesson 10.

a) Problem; What do you know about the Pythagorean Theorem? In the following figure, can you show that $a^2 + b^2 = c^2$?



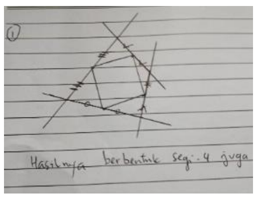
- Objective of the problem: Students can understand the concept of Pythagoras.
- Student response; Students can show that the size of angle CBE is a right angle, and can then show that a 2 + b 2 = c 2 .
- Reflection: Student solutions tend to be analytical with numerical calculations.

So, in the next learning process and in the MES class, students need to be taught mathematical logic that does not only talk about numbers.

10. Lesson 11.

b) Problem; What do you know when the midpoints of adjacent sides of a quadrilateral are connected? Give an explanation.

- Objective of the problem: Students can understand that each midpoint of adjacent sides connected in a quadrilateral will produce a parallelogram.



- Student response: Students can describe it, but cannot yet conclude with evidence that the quadrilateral formed is a parallelogram.
- Learning trajectory:
- The lecturer asks groups of students to draw a quadrilateral with its symbols. Then, they connect the midpoints of adjacent sides by naming them.
- Students describe it by naming each point.

- From the group discussion, a group of students found the answer by connecting the diagonals of the quadrilateral. Then, using the previous concept of similarity, the students found the solution: the quadrilateral formed has the property that paired sides are parallel. Thus, the students found the answer to the problem: the resulting figure is a parallelogram.

Learning in the MESP class is carried out by improving the learning process in the PSPM class, namely by reminding students that to solve mathematical problems they must understand the problem correctly and describe it correctly and precisely by providing a name or symbol.

11. 12th meeting. Implementation of stage III test.

Curriculum problem: Prove that the angle opposite the longest side is the largest.

The results of the mathematical reasoning test for students in the PSPM stage III class reached an average of 68.0 with a classical completion of 74%. Meanwhile, the results of the mathematical reasoning ability test achieved by students in the MESP class with the same test content in the PSPM class averaged 71.3 with a classical completion of 91%. These results indicate that the expected ability target through AI-assisted realistic approach-based learning has not been achieved, namely a minimum of 85% for the PSPM class, while for the MESP class it has reached the target. Thus, learning improvements still need to be made, especially for the PSPM class.

From the results of the analysis of student problem answers, it can be seen that the factors causing the failure to achieve the target for the PSPM class include the alleged ineffectiveness of the learning process used in the PSPM class, there are still study groups that are less focused on solving the problems given, even though there is an increase in achievement. Learning heterogeneous group discussions can improve student learning outcomes (Vygotsky. 1978) . Thus, subsequent learning will change group members to be heterogeneous and emphasize a complete understanding of the problem, in addition to providing insight that mathematics is not only related to numbers, but plays a role in forming a mindset.

12. Lesson 13.

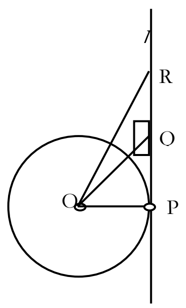
a) Problem; How do you convince others that the diameter of a circle is the longest chord? Give reasons.

- Objective of the problem: Students can show that the diameter is the longest chord in a circle.
- Student response: Through discussion, students are able to find the solution, namely by using the theorem "the sum of two sides of a triangle is greater than the third side."
- Reflection: students have understood the theorem that the sum of two sides of a triangle is greater than the length of the third side.

b) Problem: If a line touches a circle, then the line will be perpendicular to the radius passing through the point of tangency.

- Objective of the problem: Students are able to understand that only one tangent line passes through one point on a circle.
- Student response: Students can only draw a line tangent to a circle at one point on the circle.
- Learning trajectory:

1) The lecturer asked students to draw a tangent to a circle and give it a name or label.
2) Students draw it as shown on the side.
3) The student named line *l* as tangent to circle C(O, OP) at point P but OP as the radius of the circle is not perpendicular to line *l* as in the following figure.

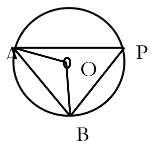


4) Then the lecturer gave a hint to draw a perpendicular line l from the center point O.
5) Students draw line OQ perpendicular to *l*. Then construct line OR such that PQ=QR.
6) The lecturer directed students to pay attention to ΔQOP and ΔQOR.
7) Finally, the students found ΔQOP ≅ ΔQOR (*side, angle, side*). Consequently, OP = OR. Next, students see that OP=OR is a contradiction of R on the circle C(O, OP). Thus, students find that OP must be perpendicular to *l*.

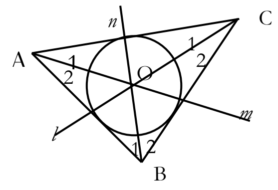
13. Lesson 14.

a) Problem; Show that twice the measure of the angle in the circumference of a circle is equal to the measure of the interior angle.

- Objective of the problem: Students can discover the concept of the circumference of a circle.
- Student response: can show with pictures, but given a little hint, namely finding two similarities.



- Reflection; need to be given lots of practice.
- Problem. How do you draw a circle in a triangle? Problem objective: Students will be able to understand and apply bisectors and perpendicular bisectors.



- Student response: Students can describe it from the definition of a circle in a triangle, namely the center point of the circle in a triangle is the intersection of the bisectors of the vertices of the triangle.
- Reflection: to enrich students' understanding, they need to be given challenging practice questions.

14. Lesson 15.

a) Problem: How do you know the area of a rectangle is length times width?

- Objective of the problem: students can understand the concept of area and find it.
- Student response: students only know the formula from what the teacher told them, and cannot prove it.
- Learning trajectory: the lecturer asks students to take two sheets of HVS paper. Then, the lecturer asks 1 sheet to be cut into squares of the same size. Then, the lecturer asks students to stick the pieces to the whole paper, and calculate them according to columns and rows. Finally, students find the formula for the area of the rectangle; L = pxl.
- Reflection: using an inductive method, the lecturer asks students to find the formula for the area of a circle, the volume of a cube, and the volume of a sphere.

15. 16th meeting. Implementation of stage IV tests.

1) Reasoning problem; Prove that a chord of a circle cut perpendicular to the diameter of the circle divides it into 2 equal parts.
2) Problem: Show that the circumference of a circle in a triangle is equal to 2 times the circumference of the triangle.

The results of the 4th stage test on the mathematical reasoning ability of PSPM class students reached an average of 75.2 with a classical completeness of 92%. Meanwhile, the results of the mathematical reasoning ability test of MESP class students reached an average of 87.0 with a classical completeness of 100%. These results indicate that the expected ability target through geometry learning based on an AI-assisted realistic approach has exceeded the target of a minimum classical completeness of 85%. Thus, geometry learning based on an AI-assisted realistic approach will be sufficient, because it has achieved effectiveness, namely learning through group discussions with 4-5 heterogeneous members each, and interactively.

RESEARCH DISCUSSION

The implementation of the development of student worksheets based on a realistic approach assisted by AI with the aim of improving the mathematical reasoning abilities of mathematics students was carried out for 12 meetings with 4 tests in the PSPM and MESP classes. The results of the research on students' mathematical reasoning abilities for each PSPM and MESP class that have been found are presented as follows.

Table 1. Results of the mathematical reasoning ability test for PSPM and MESP classes.

CLASS	PSPM				MESP			
TEST	1	2	3	4	1	2	3	4
Average	48.2	63.2	68	75.2	59.6	66	71.3	87.0
Completed (%)	0	50	74	92	18	68	91	100

The table 1 above shows that the average score for test 1 for the PSPM class was 48.2, while for the MESP class, with the same test content, it was 59.6, an improvement. This is due to the treatment in the MESP class, which included improvements to the appearance of student worksheets with images and the implementation of learning carried out through group discussions of 6-7 members, while learning in the previous PSPM class was individual.

Furthermore, the average result of the 2nd test for the PSPM class increased to 63.2 with classical completeness reaching 50%, while for the MESP class it reached 66 with classical completeness reaching 68%. The increase in the average test score in the PSPM class was due to changes in the implementation of learning from individual learning to group learning (Wang, M., et al. (2025).

The average score of the 3rd test results on the mathematical reasoning ability of PSPM class students was 68, an increase from the 2nd test of 63.2 with classical completeness to 74%, while for the MESP class, the average score was 71.3 with classical completeness of 91%. The increase in achievement in the 3rd test occurred due to improvements in the appearance of the worksheet accompanied by images and the learning was carried out by making group discussions of 4-5 students more effective (Zawacki-Richter, O., Marín, VI, Bond, M., & Gouverneur, F. 2019). Learning was continued in the 4th stage, because the achievement of completeness of the PSPM class had not yet reached completion. After the 4th stage of learning was carried out with the contents of the circle and area student worksheets accompanied by images and with a realistic approach to group discussions

. The average result of the 4th test of mathematical reasoning ability of the PSPM class was 75.2 with a classical completion of 92%, and the average reasoning ability of the MESP class was 87.0 with a classical completion of 100%. Because the target has been achieved, the classical completion of the PSPM and MESP classes is at least 85%, and is effective, then geometry learning based on a realistic approach assisted by AI is sufficient. The learning achievement is carried out through heterogeneous and interactive group learning consisting of 4-5 students.

CONCLUSION

1. During the 12 meetings of AI-assisted realistic approach-based geometry learning, it was found that the average mathematical reasoning ability of PSPM class students consistently improved, with a final score of 75.2 pounds, representing 92% of the original content. Meanwhile, the average mathematical reasoning ability of MESP class students consistently improved, with a final score of 87.0 pounds, achieving 100% classical completion, and achieving effectiveness.
2. Geometry learning based on a realistic approach assisted by AI has been effective through heterogeneous and interactive group learning of 4-5 students per group. The contextual problems presented are open-ended challenges or conflicts.
3. The stages of geometry learning through a realistic AI-assisted approach that are effective towards the mathematical reasoning abilities of students of the Mathematics Education study program in the mathematics department, Faculty of Mathematics and Natural Sciences, Medan State University are; a) Providing contextual problems in the form of realistic and challenging conflicts, b) providing the first opportunity for students to understand and solve problems individually then continued in heterogeneous discussion groups consisting of 4-5 people, c) Presenting the results of independent or group work in class interactively, and d) Finding the results or concepts contained in problem-solving models that arise in group discussions.

SUGGESTION

1. To improve students' mathematical reasoning skills, an alternative approach can be used in groups assisted by AI with student worksheets that have the following characteristics: containing definitions, axioms, and Euclid's postulates, containing contextual problems based on conflict or challenges, and sufficient enrichment problems.
2. Form a student mindset that AI is only a tool to help understand mathematics and not all mathematical problems can be solved rationally by AI.

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