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Analyzing Students' Commognitive Processes in Solving Pythagorean Theorem Problems: A Gender-Based

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Abstract: This study describes students' cognitive in solving Pythagorean theorem problems in terms of gender. The research design used is explorative with a qualitative descriptive approach. The research subjects selected were 2 students, namely 1 male student and 1 female student. Data collection was carried out using written assignments and interviews. Checking the quality of the research results using data credibility is done by extending involvement, increasing persistence, discussions with peers, and membercheck and dependability. Data analysis techniques used in this research are data condensation, data display, and conclusion drawing and verification. The results showed that male and female students had raised all commognitive indicators. Male and female students can generally bring up keywords in the form of the words "area of a right triangle $25m^2$ ", "perimeter = K", and "hypotenuse c in k". Male students wrote very brief information while female students wrote clear and complete information. The description of the solution written by male and female students is different. The differences found were the use of visual mediators such as visualizing. Male students generalized a as height, b as base, c as hypotenuse while female students generalized a as base, b as height, c as hypotenuse. Endorsed narratives carried out by male and female students can write the formula for the hypotenuse of the Pythagorean theorem, the formula for the area of a right triangle, the formula for the perimeter of a right triangle and the factoring formula. Male and female students can also express the definition of the formula in solving Pythagorean theorem problems. Routines performed by male and female students can choose the right concepts and methods so that they have a good effect on the results of their solutions.

Keywords: commognitive, pythagorean theorem, gender.

▪ INTRODUCTION

Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation and state (PPRI, 2022) . The term mathematics is very popular in society, especially in the world of education. Mathematics is a subject that is taught in the education curriculum and given to all levels of education from elementary school to university (Adila & Harisah, 2020) . One of the mathematics materials at the MTs / SMP level really needs to be understood, namely the Pythagorean theorem. Understanding this material will help in achieving understanding of subsequent materials such as tangent circle material, quadrilateral and triangle material and other mathematical materials. The Phytagorean Theorem is one of the materials among mathematics that is often associated with other mathematical materials such as flat and space building materials. In other words, the Phytagorean Theorem is a theorem used in calculating the area of flat shapes (Rangkuti & Siregar, 2019) . Rahmawati (2020) suggests that the application of the Pythagorean theorem is carried out in many fields, especially the field of architecture, architects use it to measure the slope of buildings, for example the slope of an

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embankment so that it can withstand water pressure. Apart from architecture, the Pythagorean theorem is also applied in many other fields.

The process of solving students working on Pythagorean theorem problems is not only focused on understanding concepts and counting, but also requires communication and cognition. Communication can be presented both in oral and written form (Siregar, 2018) . Communication is considered important because communication is not only addressed to others but can also be addressed to oneself as a form of pouring ideas so that it can be said to be cognitive communication (Lestari, et al, 2023) . Cognition (thinking) is defined as the process of thinking (Khiyarusoleh, 2016) . The process of cognition is related to the level of intelligence that characterizes or marks a person with various interests mainly aimed at ideas and learning (Zulfitria, et al., 2021) . Therefore, communication and cognition are closely related to the student's completion process in solving the Pythagorean theorem problem.

Communication and thinking (cognition) are combined into a new word, commognitive. This term was first developed by Sfard, a mathematician (Lefrida, et al, 2021). Commognitive is a thinking process expressed in written and oral form. (Setyowati, et al, 2022). The commognitive framework has four components, namely word use, visual mediator, narrative, and routine (Zayyadi & Pratiwi, 2022). Commognitive indicators can be used to look deeper into the cognitive made when students work on the problems and tasks given. The process of solving students' problems and tasks with commognitive is important because in seeing students' commognitive not only with the results obtained but also with the keywords, visual mediators, narrative, and routine used (Zayyadi, et al, 2023).

Some previous studies have examined the Commognitive Analysis of Students in Solving Circle Problems in Review of Learning Styles (Setyowati et al., 2022), Commognitive Students on Problem Solving SPLDV Material SMK PGRI KRAS Kediri (Santoso et al., 2024), Mathematical Commognitive Analysis of Junior High School Students in Solving Story Problems in Pairs (Lestari et al., 2023), Commognitive Analysis of Students in Solving Non-Routine Problems (Zayyadi et al., 2023). The results of the research described show that there is a diversity of studies on student cognitive in solving problems on several material topics, but previous research has not discussed much about gender.

Based on the results of the researcher's interview with a mathematics teacher at SMP Negeri 12 Palu on Monday, March 4, 2024, information was obtained that there were several students who had difficulty in solving the Pythagorean theorem problem. When solving the problem, some students made mistakes in drawing a right triangle and determining the hypotenuse, errors in drawing roots in the right segment even though the left segment was still a square form, and errors in calculating determining the square root and difference, so that students did not get the solution results for the problem. This generally happened to students of class VIII A SMP Negeri 12 Palu. The difficulties experienced by some of these students certainly vary depending on the student's ability. Differences in student abilities are also influenced by gender. As the results of research Putri and Masiyah (2019) who concluded that there are differences in the way of thinking between men and women although only small differences that allow differences in reasoning abilities in men and women. One of the factors that influence students' abilities in learning mathematics, one of which is the gender factor (Pratama, et al, 2022). This

needs to be reviewed more deeply to become the basis for teachers in improving the quality of learning, especially students' cognitive in solving problems by paying attention to gender aspects. Based on this description, the purpose of this research is to produce "Students' Commognitive in Solving Pythagorean Theorem Problems in Terms of Gender".

▪ METHOD

This research uses an exploratory research design with a qualitative descriptive approach because in this research the data produced is descriptive data obtained from data in the form of writing, words and documents that come from the sources or informants studied. This research aims to describe students' cognitive in solving Pythagorean theorem problems in terms of gender. In this study the subjects were selected based on gender. The research subjects selected were 2 students, namely 1 male student and 1 female student. Furthermore, 1 male student and 1 female student were selected who had a high mathematics ability category obtained from the report card scores of mathematics subjects in the even semester of the 2023/2024 school year. The selection of subjects was chosen based on the high mathematics ability category by paying attention to the equality of the mathematical abilities of the two. The instruments used in this study consisted of main instruments and supporting instruments. The main instrument in this research is the researcher himself. The supporting instruments in this study were written task sheets and interview guidelines. The written task sheet in this study is a written task sheet about the Pythagorean theorem. The problem used consists of 1 number taken from the book Stewart's Calculus Series (James Stewart) . The interview guideline in this study is an interview that is used in the form of an outline of questions that will be asked by the researcher about the results of the work done by the research subject. The interview process was carried out in the odd semester of 2024/2025 when students solved the Pythagorean theorem problem at SMP Negeri 12 Palu. Checking the quality of the research results using data credibility and dependability. Testing the credibility of data or trust in the data of this research was carried out by extending involvement with the subject, increasing persistence in observation by adding references, discussions with peers, and checking with the subject. Dependability in this study was carried out through a thorough audit of the entire research process by an independent auditor or through a supervisor who aims to check all researcher activities. This process starts from guidance in preparing proposals, revising proposals, guidance when carrying out research, guidance in preparing results, and revising results. The data analysis technique used in this research is qualitative data data analysis technique as stated by Miles, et al. (2014) namely data condensation, presenting data (data display) and drawing conclusions and verification. The following is the written assignment of the Pythagorean theorem in Figure 1 and the interview guidelines in Table 2 given to the subject.

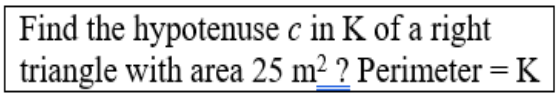

Figure 1. Pythagorean theorem written task

Table 1. Interview guidelines

Indicator Commognitive	Description	Interview Guidelines
Keywords	Students use special words "word meanings" including algebraic terms, numerical, equations, and mathematical terms in solving Pythagorean theorem problems	1. After reading the problem, what comes to your mind? 2. After reading the problem what steps did you take to solve the problem?
Visual mediator	Students use objects such as pictures, graphs, diagrams, and symbols in solving Pythagorean theorem problems	3. How do you determine a picture of the Pythagorean theorem?
Endorsed narratives	Students use definitions, formulas, theorems, and proofs in solving Pythagorean theorem problems	4. Can you explain why you use the Pythagorean theorem formula? 5. Next, why do you use the formula for the area of a right triangle? Next, try to explain why you use the formula for the perimeter of a right triangle?
Routines	The process carried out by students in solving Pythagorean theorem problems	7. Please explain the process of solving the Pythagorean theorem problem!

▪ RESULT AND DISSCUSSION

The findings show the description of male students and female students in solving Pythagorean theorem problems adjusted to the commognitive indicators namely keywords, visual mediators, endorsed narratives, and routines are as follows.

Keywords

The initial step taken by male students to find the answer to solving the Pythagorean theorem problem was to write down what was known and asked. The keywords indicator.

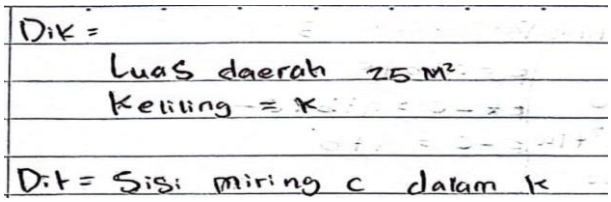

Figure 2. Male student keywords

Based on the answer results in Figure 2. In the keyword indicator, male students write the area 25 m^2, perimeter = k, and hypotenuse c in k. At the interview stage, the male student also explained the keywords he got in Table 2 below.

Table 2. Male student interviews related to keywords

	Dialog
PN-007	After reading the problem, what steps did you take?
SL-008	Find what is known and what is asked

PN-009	What information do you know from the question?
SL-010	The known area is twenty-five square meters with a perimeter equal to k
PN-011	Next, what information is asked in the question?
SL-012	Find the hypotenuse c in k

The initial step taken by female students to find the answer to solving the Pythagorean theorem problem by writing down what is known and asked. The keywords written by female students are the words "area of a right triangle", "perimeter", and "hypotenuse". Figure 3. below displays the answers written by female students on the keyword indicator.

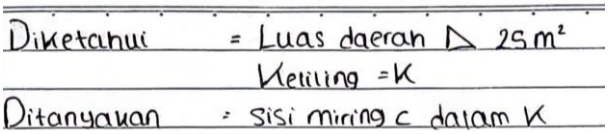

Figure 3. Famale student keywords

Based on the answer results in Figure 3. In the keyword indicator, female students write the area of a right triangle 25 m^2, perimeter = k, and hypotenuse c in k. At the interview stage, female students also explained the keywords they got in Table 3 below.

Table 3. Famale student interviews related to keywords

	Dialog
PN-005	Now after reading the question what comes to your mind?
SP-006	What is known and what is asked
PN-007	What information do you know from the question?
SP-008	The area of a right triangle is twenty-five square meters with a perimeter equal to k
PN-009	Okay, it can be written
SP-010	(*Writing*)
PN-011	(*Pointing to the problem*) From this problem, what information is being asked?
SP-012	Specifies the hypotenuse c in k

Based on the results of the analysis above, male student subjects can express the known and questionable information in the problem verbally. Male students can also write down the known and questionable information from the problem. Male students bring up commognitive indicators, namely keywords used in the form of the words “area 25m^2”, “perimeter = K”, and “hypotenuse c in k”. The male student subject wrote the information briefly. This is in line with research conducted by Tunu, et al. (2022) that male students understand what is written but write it briefly. Male students have not been able to write down information from the problem clearly and completely, but male students understand what he wrote down and are also able to retell the information contained in the problem. Female student subjects can express the known and questionable information in the problem verbally. female students can also write down the known and questionable information. Female students bring up commognitive indicators, namely keywords used in the form of the words “the area of a right triangle is 25m^2”, “perimeter = K”, and

"hypotenuse c in k". Female student subjects wrote the information clearly and completely. This is in line with research conducted by Baehaqi, et al. (2023) that when implementing the solution plan, female students are more complete in writing information.

Visual Mediator

The visual mediator indicator written by male students is visualizing images and symbols. The following Figure 4. below is the result of male students' answers on the visual mediator indicator.

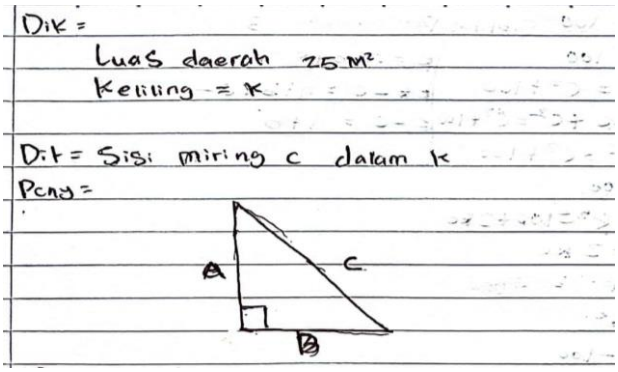

Figure 4. Visual mediators of male students

Based on the answers in Figure 4, the male students' answers on the visual mediator indicators written by male students are drawing a right triangle and memorizing the circumference = K, c as the hypotenuse, a as the height, b as the base. The researcher further confirmed the drawings and symbols written by male students with the interview process in Table 4 below.

Table 4. Male student interviews related to visual mediators

	Dialog
PN-009	What information do you know from the question?
SL-010	The known area is twenty-five square meters with a perimeter equal to k
PN-011	Next, what information is asked in the question?
SL-012	Find the hypotenuse c in k
PN-013	(*Pointing to the picture of a right triangle*) What is this picture?
SL-014	Draw a right triangle
PN-015	How do you determine the image of a right triangle?
SL-016	From the question
PN-017	(*Pointing to the formula for finding the hypotenuse of a right triangle*) What is this formula?
SL-018	Find the hypotenuse c
PN-019	How did you determine the hypotenuse formula?
SL-020	C to the power of two equals a to the power of two plus b to the power of two
PN-021	What is this C as?
SL-022	C as the hypotenuse
PN-023	A is this?

SL-024	High
PN-025	B is this?
SL-026	The base

The visual mediator indicator performed by female students is visualizing images and symbols. Figure 5. below displays the answers written by female students on the visual mediator indicator.

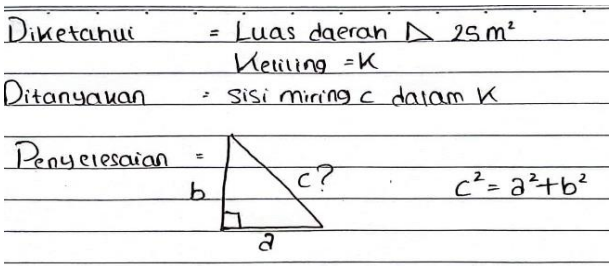

Figure 5. Visual mediators of famale students

Based on the results of the answers in Figure 5, the female students' answers to the visual mediator indicators written by female students are a picture of a right triangle and memorize the circumference = K, c as the hypotenuse, a as the base, b as the height. The researcher further confirmed the picture written by female students with the interview process in Table 5 below.

Table 5. Famale student interviews related to visual mediators

	Dialog
PN-007	What information do you know from the question?
SP-008	The area of a right triangle is twenty-five square meters with a perimeter equal to k
PN-009	Okay, it can be written
SP-010	(*Writing*)
PN-011	(*Pointing to the problem*) From this problem, what information is being asked?
SP-012	Specifies the hypotenuse c in k
PN-013	(*Pointing to the picture of a right triangle*) What is this picture?
SP-014	Right triangle
PN-015	(*Pointing to the picture of a right triangle*) Can you explain how you determined this picture?
SP-016	From the question
PN-017	(*Pointing to the formula for finding the hypotenuse of a right triangle*) What is this formula?
SP-018	Formula for finding the hypotenuse
PN-019	How did you determine the hypotenuse formula?
SP-020	The hypotenuse in question is the hypotenuse c, so here c to the power of two is equal to a to the power of two plus b to the power of two
PN-021	What is this C as?
SP-022	C is the hypotenuse
PN-023	What is this A as?

SP-024	A as a base
PN-025	How about this one?
SP-026	B as height

Based on the results of the analysis above, male student subjects bring up commognitive indicators, namely visual mediators by visualizing images and symbols, namely images of right triangles and memorizing "a as height", "b as base", and "c as hypotenuse" to make it easier to solve the problem. This is in line with research conducted by Zayyadi, et al. (2023) that there are some students who use visual mediators in a complex way, such as modeling. The female student subject brought up the commognitive indicator, namely visual mediator by visualizing images and symbols, namely a picture of a right triangle and memorizing "a as the base", "b as the height", and "c as the hypotenuse" to make it easier to solve the problem. This is in line with research conducted by Zayyadi, et al. (2023) that there are some students who use visual mediators (visual mediators) with complex, such as permissiveness. Furthermore, it is in line with research conducted by (Umaroh & Pujiastuti, 2020) that female students are able to use mathematical models well and are careful in using symbols.

Endorsed Narratives

The stages carried out by male students on the narrative indicator of the invitation are by choosing a strategy, namely by writing the formula for the hypotenuse of the Pythagorean theorem, the formula for the area of a right triangle, and the formula for the perimeter of a right triangle. Figure 6. below displays the answers written by male students on the narrative invitation indicator.

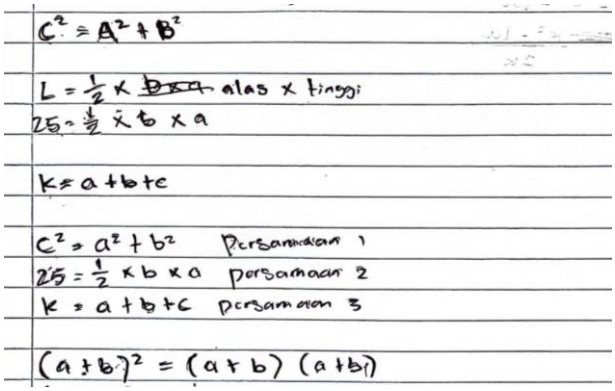

Figure 6. Male student's invitation narrative

Based on the answer results in Figure 6. In the narrative indicator, the invitation made by male students is to select the formula where male students write $c^2 = a^2 + b^2$ which is the formula for the hypotenuse of the Pythagorean theorem, $L = \frac{1}{2} \times alas \times tinggi$ namely the formula for the area of a right triangle, $K = a + b + c$ the formula for the perimeter of a right triangle and $(a + b)^2 = (a + b)(a + b)$ which is the factoring formula. The researcher conducted an interview process to explore further information related to the solicitation narrative in Table 6 below.

Table 6. Male student interviews related to narrative prompts

	Dialog
PN-017	(*Pointing to the formula for finding the hypotenuse of a right triangle*) What is this formula?
SL-018	Find the hypotenuse c
PN-019	How did you determine the hypotenuse formula?
SL-020	C to the power of two equals a to the power of two plus b to the power of two
PN-021	What is this C as?
SL-022	C as the hypotenuse
PN-023	A is this?
SL-024	High
PN-025	B is this?
SL-026	The base
PN-027	(*Pointing to the formula for the area of a right triangle*) What is this formula?
SL-028	Finding the area
PN-029	(*Pointing to the formula for the area of a right triangle*) How did you determine the area of this area?
SL-030	That is, the area is equal to one-half times the base times the height, the area is equal to twenty-five
PN-031	Where are these twenty-five from?
SL-032	The area is known, so it's equal to one-twelfth times b times a, b is the base, times a is the height
PN-033	(*Pointing to the formula for the perimeter of a right triangle*) What is this formula?
SL-034	Finding the circumference
PN-035	How did you determine the formula for the perimeter of a right triangle?
SL-036	The formula for the perimeter of a triangle is the sum of all its sides, so side a plus side b plus side c
PN-037	Explain how you determined equation one?
SL-038	Using the formula for finding the hypotenuse
PN-039	What about equation two?
SL-040	Using the triangle area formula
PN-041	What about equation three?
SL-042	By using the circumference formula
PN-043	(*Pointing to the factoring formula*) What did you use to determine this?
SL-044	Factoring formula

The stages carried out by female students on the narrative indicator of the invitation are by choosing a strategy, namely by writing the formula for the hypotenuse of the Pythagorean theorem, the formula for the area of a right triangle, and the formula for the perimeter of a right triangle. Figure 7. below displays the answers written by female students on the narrative invitation indicator.

Based on the answer results in Figure 7. In the narrative indicator, the invitation made by female students is to select a formula where female students can write down $c^2 = a^2 + b^2$ which is the formula for the hypotenuse of the Pythagorean theorem,

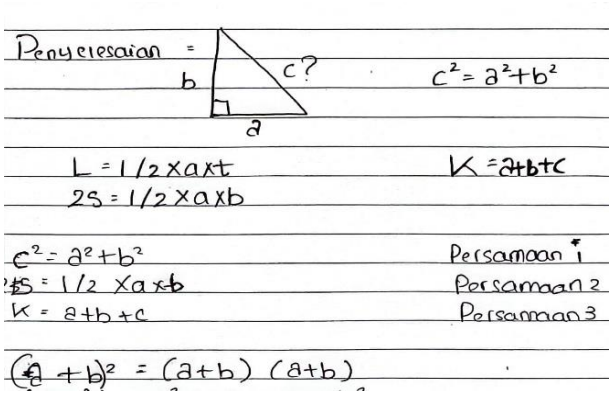

Figure 7. Narrative of female student's invitation

$L = \frac{1}{2} \times a \times t$ namely the formula for the area of a right triangle, $K = a + b + c$ the formula for the perimeter of a right triangle and $(a + b)^2 = (a + b)(a + b)$ which is the factoring formula. The researcher conducted an interview to explore further information related to the solicitation narrative in Table 7 below.

Table 7. Famale student interviews related to narrative prompts

	Dialog
PN-017	(*Pointing to the formula for finding the hypotenuse of a right triangle*) What is this formula?
SP-018	Formula for finding the hypotenuse
PN-019	How did you determine the hypotenuse formula?
SP-020	The hypotenuse in question is the hypotenuse c, so here c to the power of two is equal to a to the power of two plus b to the power of two.
PN-021	What is this C as?
SP-022	C is the hypotenuse
PN-023	What is this A as?
SP-024	A as a base
PN-025	How about this one?
SP-026	B as height
PN-027	(*Pointing to the formula for the area of a right triangle*) What is this formula?
SP-028	Triangle area formula
PN-029	Can you explain how you determined the triangle area formula, can you explain how you determined it?
SP-030	The triangle area formula is one-twelfth times the base times the height, here the area is twenty-five square meters, here twenty-five is the area, so one-twelfth times a times b, a is the base, b is the height.
PN-031	(*Pointing to the formula for the perimeter of a right triangle*) What is this formula?
SP-032	Perimeter formula
PN-033	What circumference?
SP-034	Perimeter of a triangle
PN-035	The perimeter of what triangle?
SP-036	Perimeter of a right triangle

PN-037	How did you determine the formula for the perimeter of a right triangle?
SP-038	If in the question, it means this is the sum of all sides, so here all the sides are written by finding the result which is added, this is a, b, and c the sides of the triangle will be added later.
PN-039	Can you explain how to determine this one equation?
SP-040	I can determine equation one of the formula for determining the hypotenuse
PN-041	What about how to determine equation two?
SP-042	From the formula for the area of a right triangle
PN-043	How about to determine equation three?
SP-044	From the formula for the perimeter of a right triangle
PN-045	(*Pointing to the factoring formula*) What is this formula?
SP-046	Factoring

Based on the results of the analysis above, male student subjects bring up commognitive indicators, namely endorsed narratives, showing that male student subjects write $c^2 = a^2 + b^2$ namely the formula for the hypotenuse of the Pythagorean theorem", "$L = \frac{1}{2} \times alas \times tinggi$, namely the formula for the area of a right triangle", "$K = a + b + c$, namely the formula for the perimeter of a right triangle" and "$(a + b)^2 = (a + b)(a + b)$", namely the factoring formula. Male students also revealed the definition of the formula when solving the Pythagorean theorem problem. This is in accordance with research conducted by Raharjo, et al. (2024)that male students bring up narrative is by writing down the formula used, so male students can be said to be precise in using narrative. Female student subjects bring up commognitive indicators, namely endorsed narratives, showing that female student subjects accurately write "$c^2 = a^2 + b^2$, namely the formula for the hypotenuse of the Pythagorean theorem", "$L = \frac{1}{2} \times a \times t$, namely the formula for the area of a right triangle", "$K = a + b + c$, namely the formula for the perimeter of a right triangle" and "$(a + b)^2 = (a + b)(a + b)$, namely the factoring formula". Female students also revealed the definition of the formula when solving the Pythagorean theorem problem. In addition to providing explanations, supported narratives can be useful for exploring the level of student understanding, if a student is able to explain a concept appropriately, students understand what they have written (Lestari, et al .. 2021).

Routines

The steps taken by male students in solving the Pythagorean theorem problem are shown in Figure 8 below. The steps taken by female students in solving the Pythagorean theorem problem are shown in Figure 9 below.

Based on the results of the analysis above, the male student subject brought up the commognitive indicator, namely routines by writing down what was known and asked, then mentioning the elements contained in the problem in the form of the words "area $25m^2$ ", "perimeter = K", and "hypotenuse c in k". Furthermore, visualizing images and symbols, namely a picture of a right triangle and memorizing "a as the height", "b as the base", and "c as the hypotenuse". Furthermore, male students write "$c^2 = a^2 + b^2$ which is the formula for the hypotenuse of the Pythagorean theorem", "$L = \frac{1}{2} \times alas \times tinggi$

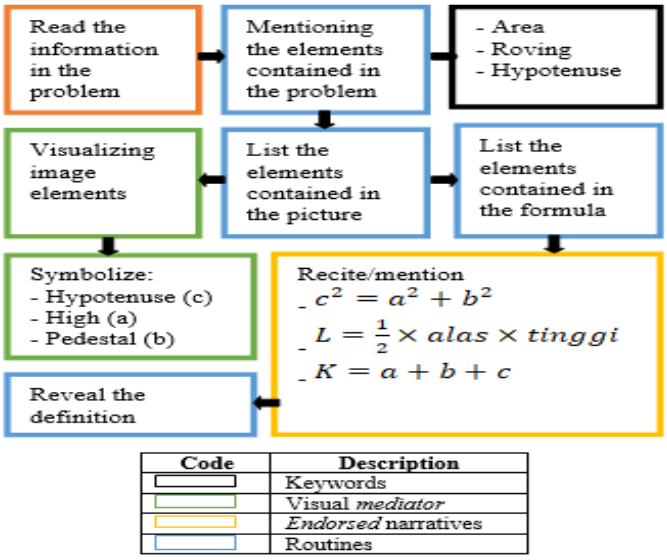

Figure 8. Male student routine

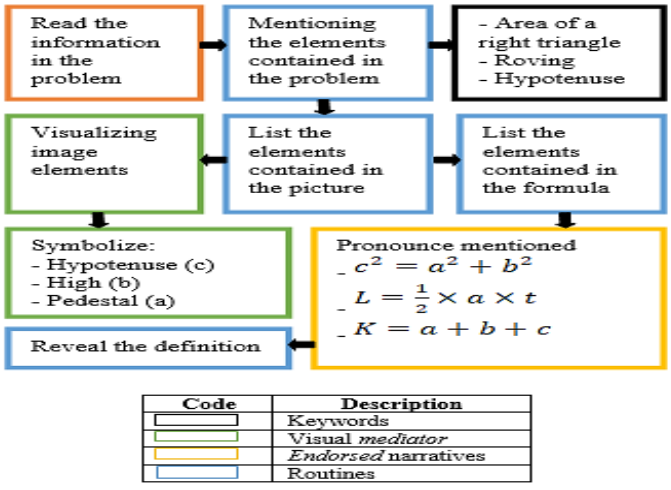

Figure 9. Female student routine

which is the formula for the area of a right triangle", "$K = a + b + c$ which is the formula for the perimeter of a right triangle" and "$(a + b)^2 = (a + b)(a + b)$" which is the factoring formula then male students carry out the solution process. Female student subjects bring up the commognitive indicator, namely routines by writing down what is known and asked, then mentioning the elements contained in the problem in the form of the words "area of a right triangle $25m^2$", "perimeter = K", and "hypotenuse c in k". Furthermore, visualizing images and symbols, namely a picture of a right triangle and memorizing "a as the base, "b as the height", and "c as the hypotenuse". Furthermore, female students write "$c^2 = a^2 + b^2$ which is the formula for the hypotenuse of the Pythagorean theorem", "$L = \frac{1}{2} \times a \times t$ which is the formula for the area of a right triangle", "$K = a + b + c$ which is the formula for the perimeter of a right triangle" and "$(a + b)^2 = (a + b)(a + b)$ which is the factoring formula". This is in line with research

conducted by Zayyadi, et al. (2023) that students can choose concepts and methods and implement the strategies they choose well which will have a good effect on the results of their solutions.

▪ CONCLUSION

Based on the results of the study, it can be concluded that male and female students have raised all commognitive indicators, namely keywords, visual mediators, endorsed narratives, and routines when solving Pythagorean theorem problems. Male and female students can generally come up with keywords in the form of the words "area of a right triangle 25m^2", "perimeter = K", and "hypotenuse c in k". Male students wrote very brief information but male students understood what he wrote and were also able to retell the information contained in the problem while female students wrote information clearly and completely. The description of the solution written by male and female students is different. The differences found were the use of visual mediators such as visualizing. Male students generalized a as height, b as base, c as hypotenuse and female students generalized a as base, b as height, c as hypotenuse. Endorsed narratives carried out by male and female students can write the formula for the hypotenuse of the Pythagorean theorem, the formula for the area of a right triangle, the formula for the perimeter of a right triangle and the factoring formula. Male and female students can also express the definition of the formula in solving Pythagorean theorem problems. Routines carried out by male students and female students.

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