Infinity Journal of Mathematics Education
Volume 14, No. 3, 2025
p-ISSN 2089-6867
e–ISSN 2460-9285
https://doi.org/10.22460/infinity.v14i3.p607-632

Analysis of mathematical communication ability on prospective elementary school teachers based on self-regulated learning level

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Received: Jun 16, 2024 | **Revised**: Feb 13, 2025 | **Accepted**: Feb 15, 2025 | **Published Online**: Jun 4, 2025

Abstract

Mathematical communication skills are essential for prospective elementary school teachers. However, many problems still occur in prospective elementary school teachers related to their mathematical communication skills. This study aims to describe the mathematical communication skills of prospective elementary school teachers and their level of self-regulated learning. This qualitative research, employing a phenomenological design, aims to explore and identify the mathematical communication skills of prospective elementary school teachers. Forty-eight prospective elementary school teachers participated in this study, and nine were selected for in-depth interviews to understand their mathematical communication skills better. The results showed that prospective elementary school teachers with high self-regulated learning almost met all indicators, prospective teachers with moderate self-regulated learning met three indicators, and prospective teachers with low self-regulated learning met one indicator. All of them were unable to provide mathematical solutions with rational reasons. Several factors cause prospective elementary school teachers not to have good mathematical communication skills, such as 1) lack of knowledge of basic geometry concepts, 2) lack of motivation to learn independently, 3) inability to manage what to learn, and 4) inability to evaluate their mistakes. Based on the research results, not all prospective elementary school teachers possess practical communication skills.

Keywords:
Mathematical communication ability, Prospective elementary school teachers, Self-regulated learning

How to Cite:
Ristiana, M. G., Wahyudin, W., Herman, T., & Nurjanah, N. (2025). Analysis of mathematical communication ability on prospective elementary school teachers based on self-regulated learning level. *Infinity Journal*, *14*(3), 607-632. https://doi.org/10.22460/infinity.v14i3.p607-632

1. INTRODUCTION

Mathematical communication ability is an important thing to have by people, especially for prospective elementary school teachers. Fahmi et al. (2017) and Rakhman (2023) state that prospective elementary school teachers should have good mathematical communication ability to be able to convey mathematical concept effectively to students. This ability is an essence of teaching, learning, and assess mathematics also as a basic assets to solve, explore and investigate mathematics problems that affect to real life problems (Hendriana et al., 2017). Mathematical communication ability is an important thing because it is a tool for exploring mathematical ideas from various perspective, to measure the growth of understanding to mathematics concepts and organizing someone's mathematical thinking (Paulus & Laurens, 2023). Someone who has high mathematical communication ability can give various representation of mathematics idea and solve mathematics problems easily (Qohar, 2011). Someone who have good mathematical communication ability will be able to absorb mathematical knowledge and solve mathematics problems easily (Ferryansyah & Anwar, 2020; Razak, 2017).

Mathematical communication ability is an ability to communicate mathematical knowledge with various form like notation, graph, diagram, table, picture, etc (Argarini et al., 2020; Baroody & Ginsburg, 1990; Mooney et al., 2021; Ningtias et al., 2020; Whitin & Whitin, 2000; Wood, 2012). There are 3 main aspects of mathematical communication ability namely 1) Drawing; 2) Writing; and 3) Mathematical expressions (Ansari, 2003; Brenner, 1998; Muhtarom et al., 2021; NCTM, 2000; Ningtias et al., 2020). Mathematical communication ability can help students understand mathematics concepts easily and they will ready to face real-life problems (Hidayat & Aripin, 2023). Teachers who can explain in simple way and systematically can reduce confusion and misconceptions that often occur in elementary school students (NCTM, 2000). This ability also teach students to analyse, interpret, evaluate mathematical information and communicate their thoughts logically and systematically (Kilpatrick & Findell, 2001). Teachers who have mathematical communication ability can create an inclusive and collaborative learning environment. So, students will encourage to more actively participate in class discussions, ask questions, and express their opinions (Boaler, 2008).

However, there are still problems that occurs in prospective elementary school teachers. One of study from Piñeiro et al. (2021) says that prospective elementary school teachers still have limited understanding of mathematical processes, especially in mathematical communication abilities. Besides that, this ability always hampered by the lack of deep conceptual understanding and effective use of mathematical language (Asmara et al., 2024; Hidayat & Aripin, 2023; Ningsih et al., 2023). Furthermore, prospective elementary school teachers' mathematical communication ability still relatively low (Turmuzi et al., 2021). These will affect teachers when teaching mathematics in elementary school because they can't explain mathematical knowledge clearly. Therefore, teachers should have good mathematical communication ability to make students understand easily, especially in elementary school.

Mathematical communication ability enables someone to express mathematical ideas clearly, either orally or in writing. Meanwhile, self-regulated learning enables someone to managing learning goals, including setting goals, adjusting strategies, and monitoring progress (Junaila & Yerizon, 2021; Qohar & Sumarmo, 2013). It seems that there is a connection between mathematical communication ability and self-regulated learning. When someone can create strategies, they can create a strategies on how they will express mathematical ideas clearly. So, one of factor that affect mathematical communication ability is self-regulated learning. Self-regulated learning is a process of planning and self-monitoring about cognitive and affective aspects to finished academic task (Desti et al., 2020). Self-regulated learning also can be define as learning process that happen because the influence of thinking, feeling, strategy, responsibility, and goal to reach something (Bosch, 2017; Boyer et al., 2014; Long, 1989; Schunck & Zimmerman, 1998). So, it can conclude that self-regulated learning is a self-managing to learn something that involves setting goals, monitoring progress, and adjusting strategies.

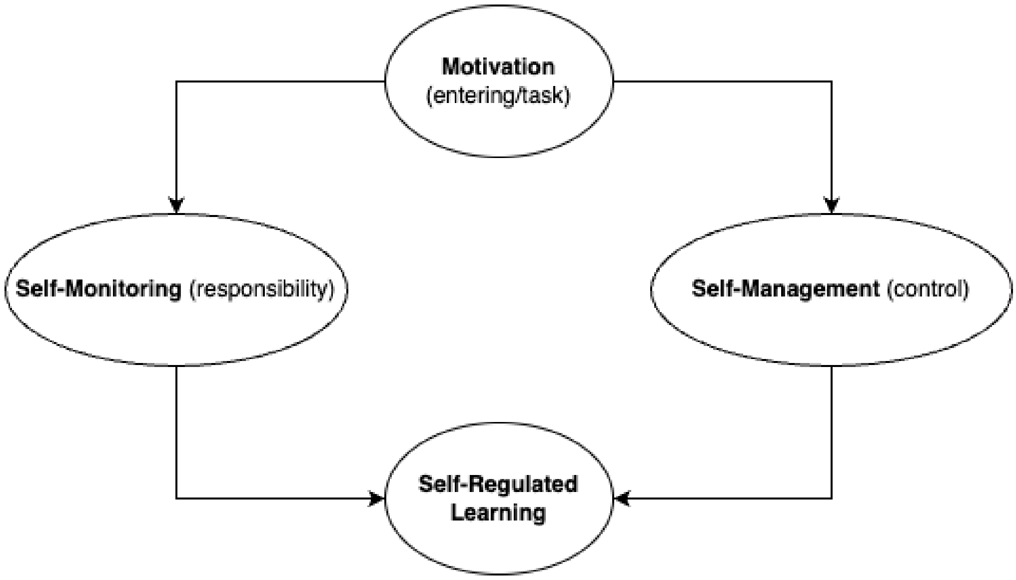


Figure 1. self-regulated learning process based on Garrison model

Based on Figure 1, self-regulated learning is a process from motivation to self-directed learning to achieve some learning goals (Bosch et al., 2019). Starting from motivation, self-management that influence choice of control in learning to achieve their goals, self-monitoring are passed to finally achieve learning independence/self-regulated learning. There are 11 aspects that can be used to measure someone's self-regulated learning, namely: 1) self-evaluating, evaluating quality and progress of the work; 2) organizing/transforming, organize to improve learning quality; 3) goal-setting/planning, set learning goals and planning step by step; 4) seeking information, looking for information from various sources; 5) monitoring, making sticky notes for self-monitoring; 6) environmental structuring, choosing comfortable place to learn; 7) self-consequences, set reward and punishment; 8) rehearsing/memorizing, remembering material by doing something; 9) seeking social assistance, asking help to friends, teachers, parents, or experts when finding difficulties; 10) reviewing records, reread notes; and 11) others, study habits initiated by other person like parents or teachers (Zimmerman, 1989).

Zimmerman (2002) said that someone who have good self-regulated learning will looking for a complete explanation of mathematical concepts, so they can understand more deeply. Besides that, reflection and motivation will affect to their understanding about mathematical concepts because they will always reflect their mathematical knowledge and have motivation to make them better (Boekaerts, 1999; Schunk, 2005). These thing will make them can explain clearly about mathematical concepts. Ali et al. (2023) and Dalimunthe et al. (2023) state that the higher self-regulated learning, the higher mathematical communication ability.

Fitrianingtyas et al. (2024) state that adversity quotient have positive and significant effect on self-regulated learning. This means that students who have good adversity quotient will have good self-regulated learning (Nur et al., 2022). Then, Muhtarom et al. (2021) found that climber students can meet all mathematical communication ability indicators. Camper students tend to meet all mathematical communication ability indicators, but not all of them. Quitter students tend not to meet all mathematical communication ability indicators. Therefore, it is necessary to conduct research on the mathematical communication skills of prospective elementary school teachers in relation to their level of self-regulated learning. So, this research aim to analysing mathematical communication ability on prospective elementary school teachers based on their self-regulated learning.

2. METHOD

This qualitative study uses a phenomenological design to explore and understand the mathematical communication skills of prospective elementary school teachers (Clark & Creswell, 2015). The mechanism of this study begins with preparing test instruments and interviews, then collecting data and analyzing it, which ends with a conclusion based on the results. Based on the results of the analysis of the phenomenon of mathematical communication skills of prospective elementary school teachers, this study needs to be expanded more generally. The subjects used were 48 (2 males and 46 females) prospective elementary school teachers from one of the universities in Bandung. The sampling method used was purposive sampling to find the best class at the University by using interviews with several lecturers. In addition, a comparison of 6 classes of mathematics learning achievement last semester was also carried out. The instruments used were a test to measure the mathematical communication skills of prospective elementary school teachers, a questionnaire to measure independent learning of prospective elementary school teachers, and interview guidelines to get more in-depth answers about their mathematical communication ability.

Table 1. Aspects and indicators of mathematical communication ability

Aspects	Indicators
Drawing	Express mathematical idea in the form of picture, graph, or diagram
	Determine and solve problems occur in the form of mathematics model
Written Text	Provide a solution of mathematical problems with rational reasons
Mathematical Expressions	Evaluate mathematical ideas in the form of picture, graph or diagram
	Define mathematics problems by manipulating picture or graph

Table 1 shows that all indicators to measure mathematical communication ability of prospective elementary school teachers with geometry materials. The mathematical communication ability indicators are compiled based on a synthesis of several indicators according to Brenner (1998), Hendriana et al. (2017), NCTM (2000), Tiffany et al. (2017), and Uyen et al. (2021). Test of geometry, especially on polygon, trilateral, and quadrilateral was made by using indicators on Table 1. Whereas, aspects and indicators of self-regulated learning are taken from Zimmerman (1989) that can be seen on Table 2.

Table 2. Aspects and indicators of self-regulated learning

Aspects	Indicators
Goal setting and *Planning*	Plan and choose how to learn something
Self-Evaluating	Self-management in commitment of learning something
	Overcome problems faced when learning something
Seeking Information	Use and utilize various source to learn something
Keeping Records and *Monitoring*	Monitor and evaluate advantages and disadvantages when learning something

In addition to the test and questionnaire, a semi-structured interview was conducted to analyze their test answers in more detail. The interview questions focused on the answers of prospective elementary school teachers for each number. After all the instruments were made, content validity was carried out for the test, questionnaire, and interview conducted by three experts. In contrast, the empirical validity of the test was performed on prospective elementary school teachers in their final year. The test, questionnaire, and interview instruments had good content and minor revisions based on the content validity. Then, based on empirical validity, the test was valid and reliable for use in the study.

After collecting data using tests and questionnaires, it was analyzed by scoring the mathematical communication ability test and the independent learning questionnaire using SPSS 29 and Microsoft Excel software. The prospective elementary school teachers were then categorized based on their level of independent learning. To determine the scores that fall into the low, medium, and high categories, determine the minimum and maximum scores. Then, look at the difference between the minimum and maximum and divide by three to see the interval between each category.

Interviews were conducted after analyzing the level of independent learning of prospective elementary school teachers based on questionnaires and mathematical communication ability scores based on tests. Then, three people with unique answers from each level of independent learning were selected to conduct interviews about their mathematical communication ability test answers (nine people were interviewed). Then, their test answers were analyzed, and each indicator of mathematical communication ability was interviewed. Finally, the results of the analysis were concluded to create new research results.

3. RESULTS AND DISCUSSION

3.1. Results

First of all, the scoring mathematical communication ability and self-regulated learning (SRL) by totalling each score of question, and analysed with SPSS 29 software to get descriptive data in Table 3.

Table 3. Statistics descriptive of mathematical communication ability and SRL

Ability	N	Mean	Minimum	Maximum
Mathematical Communication	48	60.67	28	83
Self-regulated learning (SRL)	48	62.65	36	79

Table 3 show that average score of mathematical communication ability is 60.67, maximum score is 83 and minimum score is 28. The average score of self-regulated learning is 62.65, maximum score is 79 and minimum score is 36. After scoring self-regulated learning, we categorized them into 3 level: low, moderate, and high using Microsoft Excel software (see Table 4).

Table 4. Self-regulated learning category level

Score	Category	Total
$x \leq 59$	Low	17
$59 < x < 66$	Moderate	19
$x \geq 66$	High	12

Based on Table 4, we can see that 17 prospective elementary school teachers still have low self-regulated learning, 19 have moderate self-regulated learning and 12 have high self-regulated learning. It can be conclude that most of prospective elementary school teachers have low self-regulated learning.

Table 5. Crosstab of mathematical communication ability level and SRL level

		Self-regulated learning (SRL)		
		Low SRL	**Moderate SRL**	**High SRL**
Mathematical communication ability	**Low**	4	5	5
	Moderate	10	7	1
	High	3	7	6

Table 5 shows that there are 14 prospective elementary school teachers that have low mathematical communication ability (29.16%), 18 prospective elementary school teachers that have moderate mathematical communication ability (37.5%), and 16 prospective elementary school teachers that have high mathematical communication ability (33.3%). Also, we can see that not all high self-regulated learning prospective elementary school teachers have high mathematical communication ability, and not all low self-regulated learning prospective elementary school teachers have low mathematical communication ability.

After we have self-regulated learning level and mathematical communication ability score on prospective elementary school teachers, we interviewed 3 person from each self-regulated learning level that have the highest mathematical communication ability (MCA) score. Subject data that we interviewed can be seen in Table 6.

Table 6. MCA score and SRL level

Name	MCA Score	SRL Level
S15	68	Low
S16	70	Low
S17	73	Low
S31	62	Moderate
S35	83	Moderate
S36	83	Moderate
S46	70	High
S47	72	High
S48	74	High

Table 6 shows that self-regulated learning doesn't affect mathematical communication ability because higher self-regulated learning not necessarily higher mathematical communication ability. This may caused by other factors beside self-regulated learning that have stronger effect for prospective elementary school teachers. Appart from that, we can't conclude just by looking at the mathematical communication ability scores because prospective elementary school teachers at each level may achieve different mathematical communication ability indicators. Therefore, we do analysed their mathematical communication ability from each indicators regardless of their self-regulated learning level.

3.1.1. Express mathematical idea in the form of picture, graph, or diagram

Question 1:

> *Someone has a square paper that have area of 729 cm^2 to make a kite. He will make one kite with that paper. (a) Draw a kite with length for each side and diagonal! (b) Calculate the maximum area of the kite!*

All prospective elementary school teachers don't draw the kite properly, they just draw a kite without put a length for each side and diagonal. But they know that the side length of the square is 27 cm. Some people realize that there is a connection between square and kite characteristics. So, they assume that kite can made from square. Not all prospective teachers understand that "all square is a kite" based on characteristics. It can be seen from their answer they just used area of kite formula using length of square (see Figure 2).

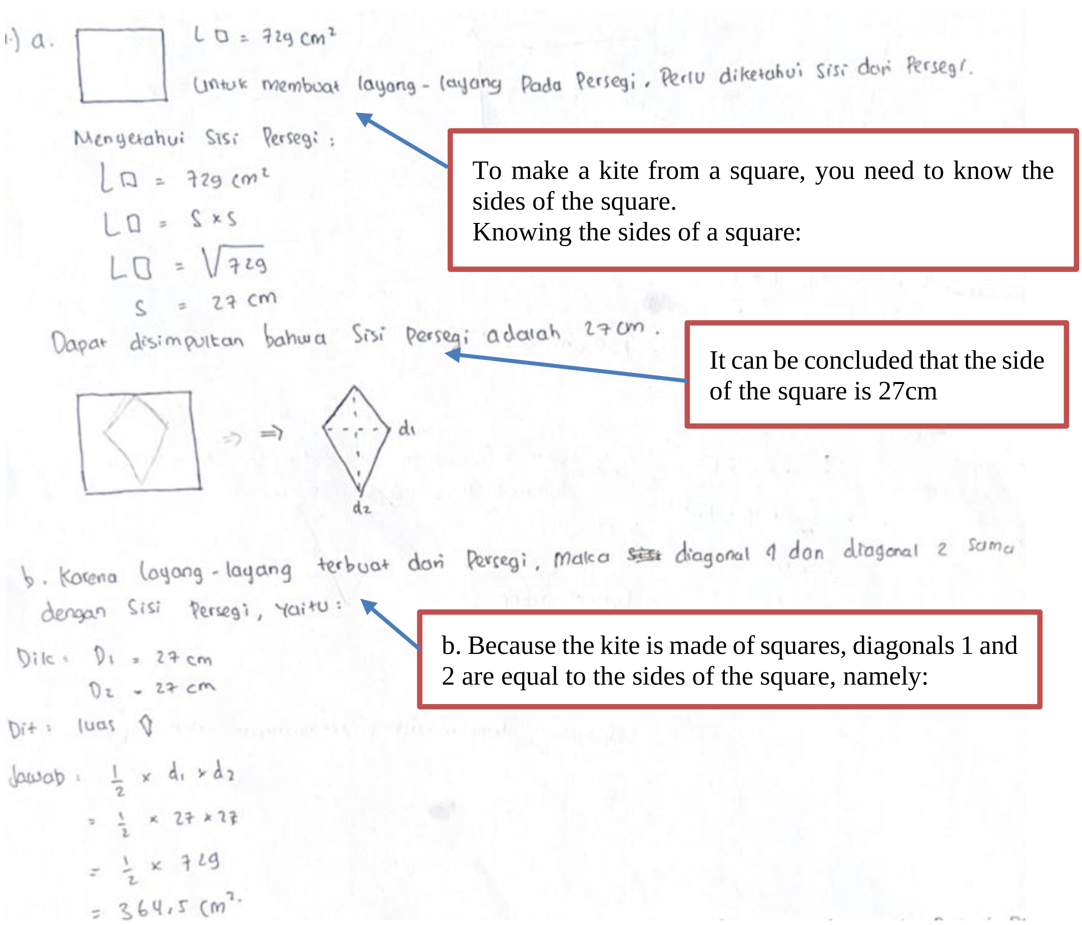


Figure 2. Less precise answer to have maximum area of kite

Some prospective elementary school teachers answer (b) like in Figure 2, using length of square (27 cm) as both diagonals.

R : *How do you find the diagonals of the kite?*

S15 : *First, I looked for the side of the square by rooting 729 cm^2 is 27 cm. Because the instructions were to make a kite, I thought all the rhombuses were kites. So, to make it I decided both diagonals were 27 cm.*

R : *Do you think it will become the maximum area of kites?*

S15 : *Yes, of course, because it's the biggest one*

Two prospective elementary school teachers in low category and one prospective elementary school teacher in moderate category answer question number 1 like this. Based on the interview, we can see that she understands the connection between one and other shapes characteristics, but not all shapes. She forgot about all squares are kites. So, she thinks that kites with both diagonals 27 cm are the biggest kite that she can make with 27×27 square paper.

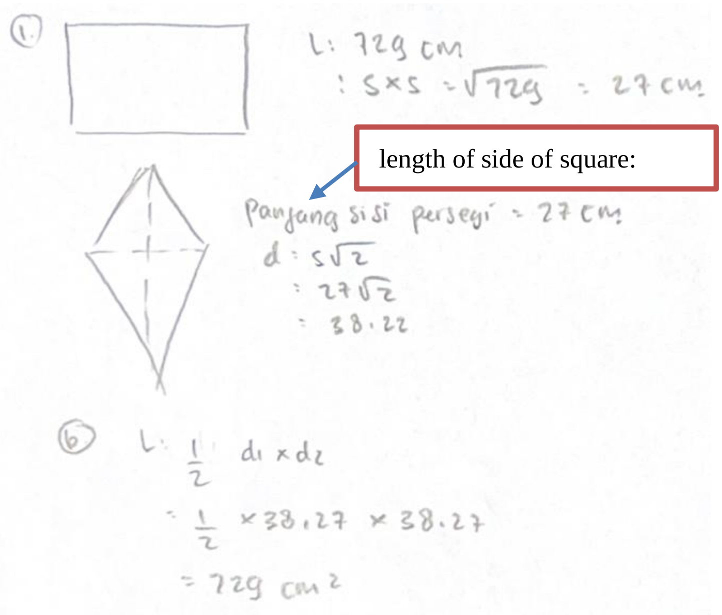


Figure 3. Correct answer to have maximum area of kite

Figure 3 shows that 6 out of 9 prospective elementary school teachers give correct answer to have maximum area of kite, one from low self-regulated learning, 2 from moderate self-regulated learning and 3 from high self-regulated learning.

R : *How do you find the diagonals of the kite?*

S36 : *It tells that area of square is 729 cm^2, to find the length of square I am rooting it and find 27 cm. Then, I used Pythagoras theorem to find the diagonal of that square, I find $27\sqrt{2}$ cm. Finally, I used area of kite formula to find it, so it's still 729 cm^2.*

R : *How do you know 729 cm^2 is the maximum area?*

S36 : *As you teach me that all squares are kites, so I think to looking for the diagonal by using Pythagoras theorem and find both diagonals are $27\sqrt{2}$ cm.*

R : *Is there any kite bigger than that?*

S36 : *I think no, because the square paper just has 729 cm^2 area.*

Based on the interview, she knows that squares and kites have a connection, so she concludes that all squares are kites. Therefore, she can find the biggest area of kites from 27×27 square paper. The case is a little bit different for S48 how she finds the maximum area of kites.

R : *How do you find the diagonals of the kite?*

S : *You tell us about the connection between squares and kites, all squares are kites. I wasn't going to look for the diagonals of the kite because I know the maximum area of the kite is 729 cm^2, but the question made me to do it. So, I'm rooting the area of square and find the diagonals which is if 2 sides are same the longest length will be $a\sqrt{2}$. Because the area of square is 729 cm^2 so the length of square is 27 cm. Therefore, I know that the diagonals are $27\sqrt{2}$ cm.*

R : *So, why you do not draw the diagonals of the kite?*

S48 : *I'm sorry, I forgot to draw it.*

Based on the interview, she knows from beginning the maximum area of the kite is 729 cm^2 because she knows that all squares are kites. She also knows that the diagonals are $27\sqrt{2}$ cm when she knows the length of square is 27 cm. But she forgot to write the diagonals of the kite.

Based on the analysis data, we can conclude that all prospective elementary school teachers with high self-regulated learning and some with moderate self-regulated learning can express mathematics idea in the form of picture, graph or diagram very well. However, prospective elementary school teachers with low self-regulated learning can express mathematics idea in the form of picture, graph or diagram but not very well.

3.1.2. Determine and solve problems occur in the form of mathematics model

Question 2:

An architect will design swimming pool in the form of rectangle. One pair of side has two half times from other pair of side. (a) make a mathematics model to find the area and circumferences of the rectangle based on the information before! (b) If the shorter pair side is 4 m, what's the area and the circumferences of that swimming pool?

Some of prospective elementary school teachers made mathematics model properly. Some of prospective elementary school teachers think that mathematics model mean geometry model, so they draw a rectangle with each length. After that, they all do the same to find the area and circumferences of the swimming pool with shorter pair side is 4 m.

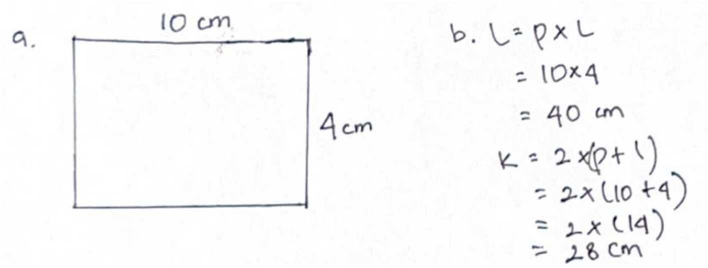


Figure 4. Geometry model as mathematics model

Figure 4 shows that prospective elementary school teachers think formal mathematics model is a geometry model. Less prospective elementary school teachers make a formal mathematics model for area and circumferences of the swimming pool.

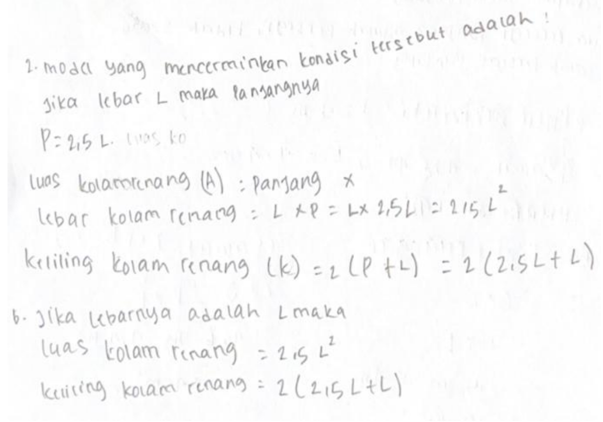
R : *What do you think when you asked to make formal mathematics model?*

S35 : *Because the test about geometry, I think mathematics model is about making a geometry shape.*

R : *How do you find each pair side of the swimming pool without formal mathematics model?*

S35 : *I used the (b) question that shorter pair side is 4 m. Because one pair of side has two half times from other pair of side, so I know that other pair side is 10 m that find by 2.5×4=10m.*

Based on the interview, prospective elementary school teachers that in low self-regulated learning level assume that mathematics model in accordance with the topic. If the topic is geometry so it will become a picture of geometry.



Translate:
2. The model that reflects the condition is:
if the width is l then the length is
$p = 2.5\ l$
The area of the swimming pool (A) = length x width = l x p = l x $2.5\ l = 2.5\ l^2$.

b. If the width is l, then the area of the swimming pool = $2.5\ l^2$
the circumference of the swimming pool = $2\ (2.5l + l)$.

Figure 5. Correct answer to make mathematics model form

Difference with prospective elementary school teachers in high and moderate self-regulated learning level (see Figure 5), they understand how to make mathematics model area and circumferences of the swimming pool. they make mathematics model for area and circumferences with the information that one pair of side has two half times from other pair of side. So, they can make area mathematics model is $A=2.5l\times l=2.5l^2$ and circumferences mathematics model is $C = 2(2.5\ l + l)$.

R : *What do you think when you asked to make formal mathematics model?*
S47 : *I think that mathematics model is an equation or a polynomial model. So, because one pair of side has two half times from other pair of side, I conclude that the area of the swimming pool will be $2.5l^2$ and the circumferences will be $2(2.5l+l)$.*
R : *Why do you not finish the (b) question with 4 m of one pair side?*
S47 : *Oh ya, I forgot to do it because struggling finding the answer for (a) question.*

Based on the interview, we can see that she understands about mathematics model and can find the models for area and circumferences of the swimming pool. But not all prospective elementary school teachers understand this.

Based on the analysis data, we can conclude that a few prospective elementary school teachers understand how to make mathematics model with the information given. Some of prospective elementary school teachers can answer the (b) question but not giving the mathematics model.

3.1.3. Provide a solution of mathematical problems with rational reasons

Question 3:

If A is a set of all parallelograms, B is a set of all rhombuses and C is a set of all kites. Draw a Venn Diagram that shows the relationship between these three sets!

This question purpose is to see whether prospective elementary school teachers can see the relationship between one and other shapes with their rational reasons. Most of prospective elementary school teachers, in fact almost none of them answered correctly.

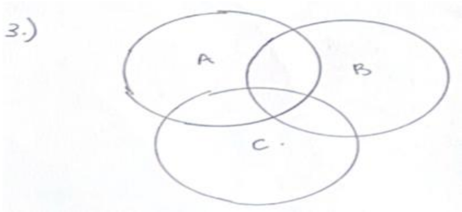


Figure 6. Wrong answer to make Venn diagram

Almost all prospective elementary school teachers answered question 3 same as Figure 6. They confused about making Venn Diagram of the relationships between rhombuses, parallelograms, and kites. So, they just make 3 circles that connect to all sets without understanding that Venn Diagram relationships.

R : *How's the relationships between a set of rhombuses and a set of parallelograms?*
S36 : *I think all of rhombuses is parallelogram because rhombus is a parallelogram with all side have the same length.*
R : *Now, how's the relationships between a set of rhombuses and a set of kites?*
S36 : *All rhombuses is kites because rhombus is a kite that diagonals intersect at right angles and are divided into two equal lengths.*
R : *So, why you make Venn Diagram like that (Figure 6)?*
S36 : *I forget about set materials, especially when I should to make Venn diagram. I hadn't studied that material for a long time.*

Based on the interview, she understands about the characteristics of each shape, but forget about making Venn Diagram because she hadn't studied that material for a long time. However, there are some prospective elementary school teachers that answer almost correct. They understand how the relationships between shapes works, but they still need to understand about all of the characteristics each shape.

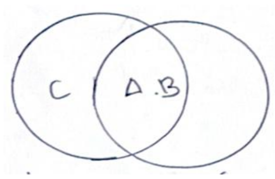


Figure 7. Less precise answer to make Venn diagram

Figure 7 shows that the answer is almost correct, there is misconception about the characteristics of each shapes set A, B and C. The correct answer should be set B is an intersect of set A and set C. So, the set of rhombuses is an intersect of the set of parallelograms and the set of kites.

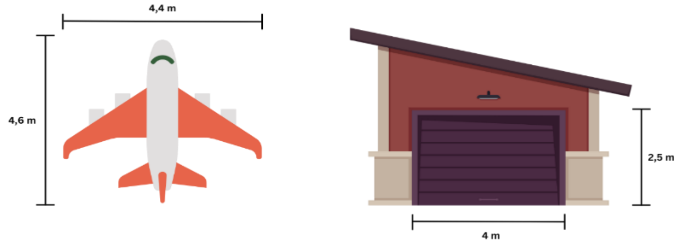
R : *How's the relationship between a set of rhombuses and a set of parallelograms?*
S30 : *All rhombuses are a parallelogram, but not all parallelograms are a rhombus.*
R : *How's the relationship between a set of rhombuses and a set of kites?*
S30 : *All rhombuses are a kite, but not all kites are a rhombus.*
R : *So, how the relationship between a set of rhombuses, a set of parallelograms and a set of kites?*
S30 : *I think rhombuses is an intersect of parallelograms and kites.*

R : *So, why you make Venn Diagram like that (Figure 7)?*
S30 : *I still confused how intersect in Venn diagram, so I make it like that.*

Based on the interview, we can see that she understands about the relationship between set of rhombuses, set of parallelograms and set of kites. However, her Venn Diagram still not perfect and need to revise.

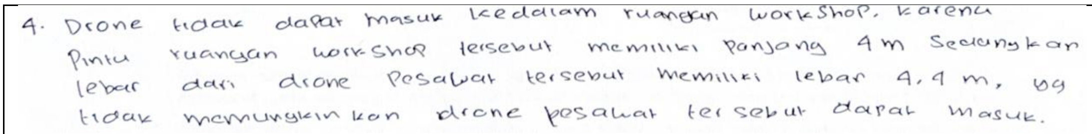
Question 4:

A drone plane makers will put his drone to his workshop room. The door of the workshop room has dimensions 4m×2.5m and the drone has dimensions 4.4m×4.6m (see picture).



Do you think the drone can enter the workshop room? Explain!

This question will test prospective elementary school teachers to use their logic "is it possible to put the drone enter the workshop room?". Some of prospective elementary school teachers answer the drone can enter the workshop room, but without any detail explanation. Some of them said that the drone can't enter the workshop room because the dimension of the drone is bigger or longer than the workshop door. And some of them said that the drone can't enter the room because the area of drone is larger than the area of workshop door.


4. Drone tidak dapat masuk kedalam ruangan workshop, karena Pintu ruangan workshop tersebut memiliki Panjang 4 m Sedangkan lebar dari drone Pesawat tersebut memiliki lebar 4,4 m, yg tidak memungkinkan drone pesawat tersebut dapat masuk.

Translate:

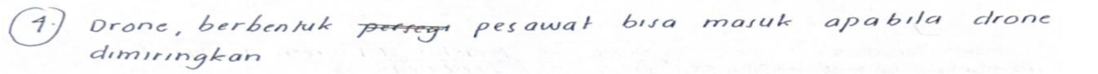
4. The drone cannot enter the workshop room, because the door of the workshop room is 4 m long, while the width of the drone aircraft is 4.4 m, which does not allow the drone aircraft to enter.

Figure 8. Students' answer who thinks directly without trying to look for another solution

Some of prospective elementary school teachers answered like in Figure 8, they said "the drone can't enter the workshop room because the size of the door 4m×2.5m is smaller than the size of drone 4.4m×4.6m.

R : *When you first read this problem, what came to your mind regarding solving this problem?*
S15 : *I think the drone can't enter the room because the size of the door is smaller than the size of the drone. No side can fit drone's wing size or drone's body size.*
R : *Are you sure about that? Have you looked for another way to solve it?*
S15 : *Yes, I have but I think there's no another way to solve it*

Based on the interview, we can see that she concludes at the first read the problem that the drone can't enter the workshop room because the door size is smaller than the drone size. Moreover, she didn't try to find another way to solve the problem.



Translate:

4. Drones can enter if the drone is tilted.

Figure 9. Students' answers that said drone can enter workshop room without any explanation

Some of prospective elementary school teachers answered "Airplane-shape drone could enter the workshop room if the drone tilted" (see Figure 9). However, they didn't answer with any evidence. They didn't know how to ensure whether the drone can enter the workshop room or not.

R : *When you first read this problem, what came to your mind regarding solving this problem?*
S16 : *The drone can enter the workshop room if it's tilted.*
R : *How to ensure that the drone can enter the workshop room?*
S16 : *I don't know, I just think if the drone tilted it can enter the workshop room.*

Based on the interview, we can see that she didn't know how to ensure the drone can enter the workshop room. She just thinks that the drone can enter the workshop room if it is tilted.

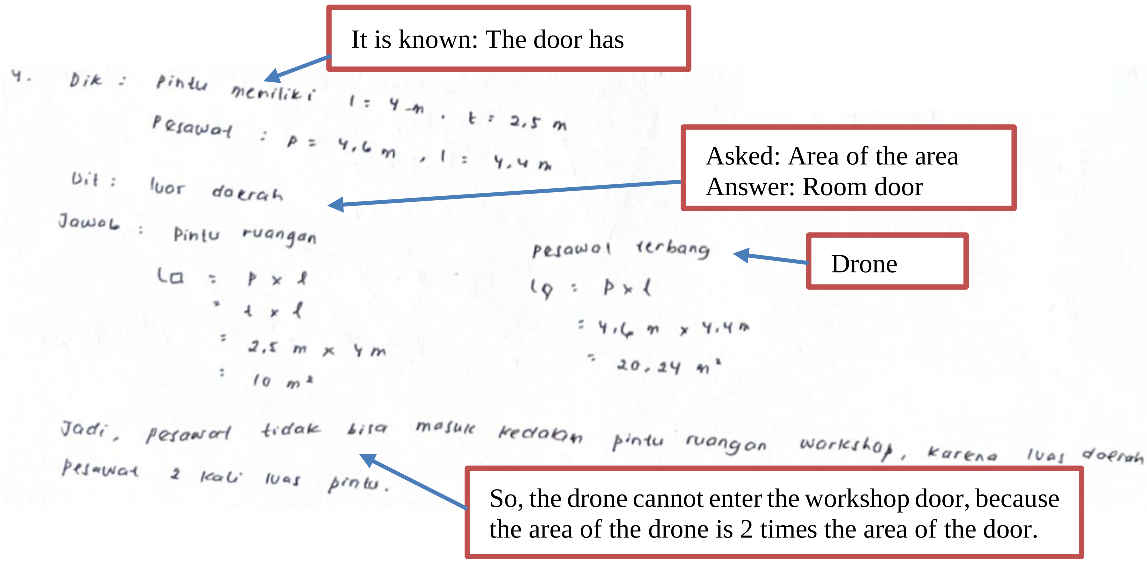


Figure 10. students' answer who thinks to looking for solution using area of the door and the drone

Some of prospective elementary school teachers (see Figure 10) think that the solution of this problem is using the area of workshop door and the area of drone. Based on Figure 10, we can see that some prospective elementary school teachers find the area of the drone just multiplied the size of the drone without thinking about what the drone looks like.

R : *When you first read this problem, what came to your mind regarding solving this problem?*
S31 : *The drone can't enter the workshop room because the area of drone is bigger than the area of workshop door.*
R : *What's the area of drone and workshop door? How can you find them?*

S31 : *For drone I just multiplied the dimensions of drone, 4.4m×4.6m=20.24m^2 and the area of workshop door is 4m×2.5m=10m^2. As we can see that area of workshop door is smaller than the area of drone. So, the drone can't enter the workshop room.*

R : *Why were you looking for the area of the drone and the workshop door?*

S31 : *I think if we want to pass the workshop door, we should know the area of drone and the area of workshop door. So, we just compare the area of drone and the area of workshop door. Because the area of drone is bigger than workshop door, the conclusions is drone can't enter the workshop room.*

Based on the interview, we can see that she had an understanding that the drone had to be the same area or smaller than the workshop door. Whereas, to determine whether the drone can enter the workshop room we do not need to use the area of drone and the area of workshop door.

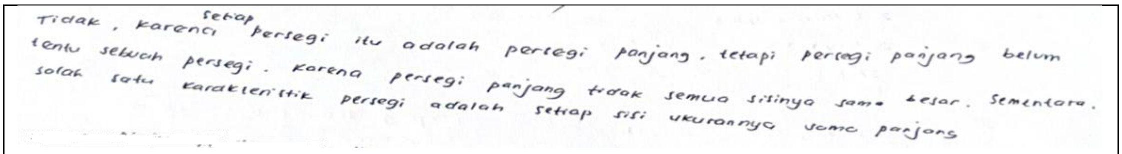
Based on the analysis data, we can conclude that most of prospective elementary school teachers still can't provide a solution of mathematical problems with rational reasons. This happens because most of them not understand about the mathematical concept. Therefore, most of them can't find a solution with many ways.

3.1.4. Evaluate mathematical ideas in the form of picture, graph or diagram

Question 5:

A student has understanding that all squares are rectangles which means all rectangles are squares. In your opinion, is the students' understanding, correct? Give the reason!

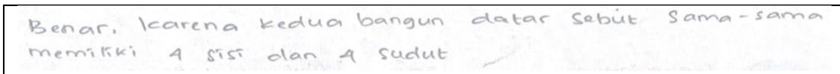
Some of prospective elementary school teachers said that students' understanding is correct, and some of them said that students' understanding need to be fixed.


Tidak, karena setiap persegi itu adalah persegi panjang, tetapi persegi panjang belum tentu sebuah persegi. Karena persegi panjang tidak semua sisinya sama besar. Sementara, salah satu karakteristik persegi adalah setiap sisi ukurannya sama panjang

Translate:
No, because every square is a rectangle, but a rectangle is not necessarily a square because a rectangle does not have all the same size sides, while one of the characteristics of a square is that all sides are the same length.

Figure 11. Prospective elementary school teacher correct answer

Some of them said that "students' understanding about all squares are rectangles is right, but all rectangles are squares is wrong (see Figure 11). It's because there are some rectangles that not all sides are the same length. Whereas opposite sides of every square are the same length." Most of them who have correct answer are in moderate and high category of self-regulated learning.


Benar, karena kedua bangun datar sebut sama-sama memiliki 4 sisi dan 4 sudut

Translate:
True, because both flat shapes have 4 sides and 4 corners.

Figure 12. Prospective elementary school teacher wrong answer

Some of them (see Figure 12) said that "students' understanding is right because every square and all rectangles have 4 sides and 4 angles". Most of prospective elementary school teachers that have wrong answer are in low category of self-regulated learning.

R : *When you read the problem, what do you think about students' understanding about squares and rectangles?*
S16 : *I think he's right because squares and rectangles have 4 sides and 4 angles, so students' understanding about all squares are rectangles and every rectangles are squares is right.*
R : *How about the size of all angles and the length of all sides between squares and rectangles?*
S16 : *The size of all angles is same, either in squares or rectangles, also the length of squares and rectangles the opposite sides are the same length. So, I conclude that all squares are rectangles, and all rectangles are squares.*

Based on the interview, we can see that prospective elementary school teacher who have low self-regulated learning category still not understand about the relationship between one and another quadrilateral.

R : When you read the problem, what do you think about students' understanding about squares and rectangles?
S48 : Not all that students' understanding right. All squares are rectangles are right because the opposite sides of squares are the same length. But all rectangles are squares are wrong because there are some rectangles that not all sides are the same length as square.

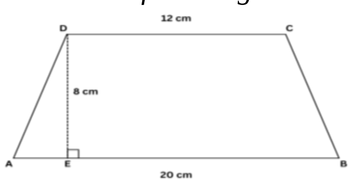
This is different from prospective elementary school teachers who have moderate and high self-regulated learning categories. Based on the interview, we can see that prospective elementary school teacher can evaluate students' understanding about the relationship between squares and rectangles.

Based on the analysis data, we can conclude that some of prospective elementary school teachers who have moderate and high self-regulated learning categories can evaluate mathematical ideas when they faced a problem. Different from prospective elementary school teachers who have low self-regulated learning category still can't evaluate mathematical ideas. They do not understand fully about mathematical concept that have been learned before. So, it makes prospective elementary school teachers have less wide thinking.

3.1.5. Define mathematics problems by manipulating picture or graph

Question 5:

Look at the following isosceles trapezoid.



(a) Turn it into a rectangle that have the same area as the following isosceles trapezoid!
(b) Calculate that area using the area of the rectangle!

Some of prospective teachers can turn the isosceles trapezoid into rectangle, and some of them can't turn it into rectangle. They just finished the task (b) using area of trapezoid formula.

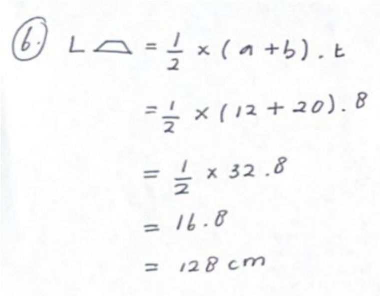


Figure 13. Students' answer who just finished task (b) using area of trapezoid

Figure 13 provide the answer of low self-regulated learning prospective elementary school teacher who just finished task (b) using area of trapezoid. As we can see, she doesn't turn isosceles trapezoid into rectangle as task (a) ask. She just finds the area of isosceles trapezoid.

R : *Why don't you turn this isosceles trapezoid into rectangle?*
S15 : *I don't know how to turn it into rectangle.*
R : *Because you don't know, so you just looking for the area of isosceles trapezoid with its formula?*
S15 : *Yes. Because I think the main problem of this question is looking for isosceles trapezoid area, so I just used its area formula.*

Based on the interview, we can see that she doesn't know how to turn isosceles trapezoid into rectangle and just finished task (b) because she thinks that the main problem of the question is looking for isosceles trapezoid area.

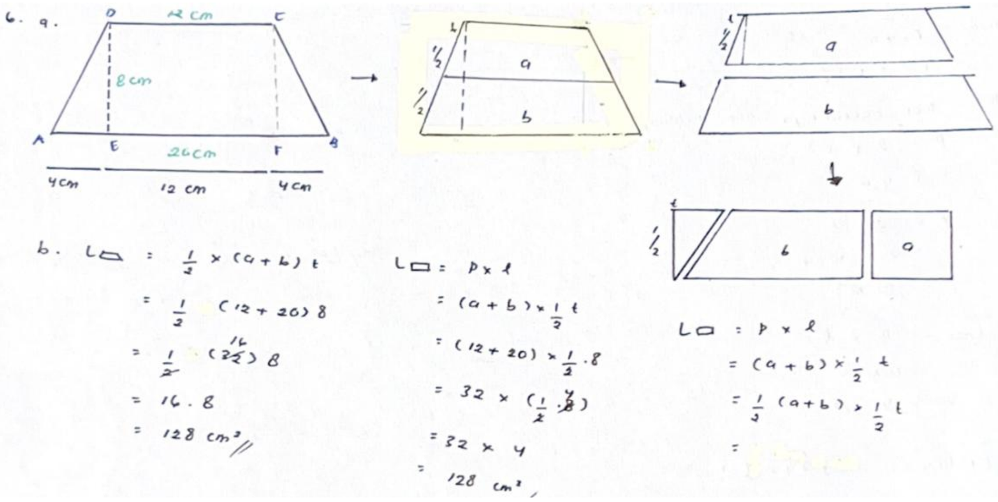


Figure 14. Prospective elementary school teacher correct answer (moderate SRL)

Figure 14 shows that provide moderate self-regulated learning prospective elementary school teacher answer, she can finish task (a) and (b). She chooses to cut the isosceles trapezoid into half and arrange it into rectangle.

R : *When you read the task (a), how do you turn isosceles trapezoid into rectangle?*

S35 : *I just cut half the isosceles trapezoid into two parts, then arrange it until it looks like a rectangle.*

R : *When you cut it, you know that the size of each side is change. So, why do you think there are sides that the size is a+b or 12+20?*

S35 : *Emh.. just cut it and flip it, so there are sides that the size is a+b?*

R : *Are you sure about that?*

S35 : *Emh.. Yes, I think*

Based on the interview, we can see that she can cut half isosceles trapezoid into two parts and arrange it until it turn into rectangle. However, she looked doubtful when asked about her answer.

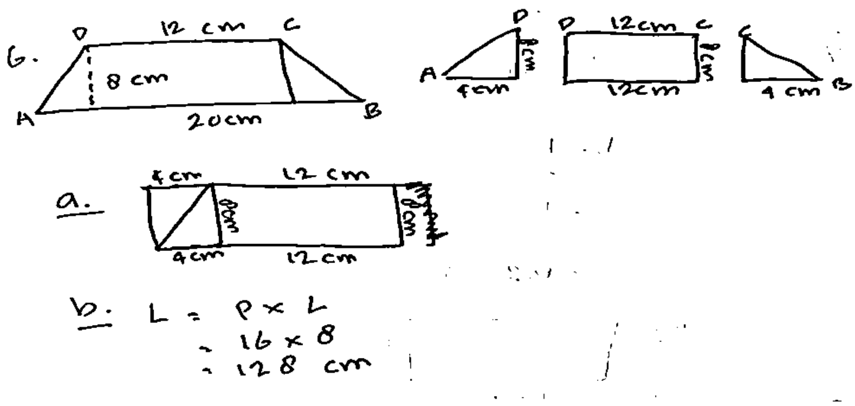


Figure 15. Prospective elementary school teacher correct answer (high SRL)

Figure 15 provide the answer of high self-regulated learning prospective elementary school teacher. As we can see that the answer is simpler and more confident. She chooses to cut isosceles trapezoid into three parts, one rectangle and two triangles with length on each side. After that, she arranges it into a rectangle with length on each side. Then, she can finish task (b) with area of rectangle formula.

R : *When you read the problem, what came to your mind to finish the task (a)?*

S48 : *I remember when you teach us about different shapes but have same area. So, I decide to cut that trapezoid into three parts, one rectangle and two triangles.*

R : *How do you know the length of each side?*

S48 : *I know that opposite sides on rectangle have the same length. So, the rectangle have 12 cm and 8 cm length.*

R : *How about the triangles? How do you know the length of each side?*

S48 : *The total length of bot side is 20 cm. Because 12 cm is already use by rectangle, so the total bot side of both triangles is 20-12=8 cm. After that, I divided it by 2 because this is isosceles trapezoid, so the length of bot triangle sides will be the same. 8:2=4 cm, so I know that the bot side of triangle is 4 cm and the other is 8 cm.*

R : *So, how about the task (b)? how do you solve it?*

S48 : *After I turn isosceles trapezoid into rectangle, I just used the area of rectangle formula p×l. The length of that rectangle are 16 cm and 8 cm. So, the area of the rectangle or the isosceles trapezoid is 128 cm^2.*

Based on the interview, we can see that high prospective elementary school teacher can manipulate isosceles trapezoid into rectangle very well. She also can used area of rectangle formula to find the area of isosceles trapezoid.

Based on the data analysis, we can conclude that low self-regulated learning prospective elementary school teachers still can't manipulate picture to solving the problem, moderate self-regulated learning prospective elementary school teachers can manipulate picture to solving the problem but still don't understand how to find the length of each sides, and high self-regulated learning prospective elementary school teachers can manipulate picture to solving problem very well without any problem.

Based on the analysis of each question and each mathematical communication ability indicators, we can conclude that: (a) Low self-regulated learning prospective elementary school teachers 1) can express mathematical ideas in the form of picture but not very well; 2) can determine and solve problems in the form of mathematics model clearly; 3) still can't provide a solution with rational reasons; 4) still can't evaluate mathematical ideas; and 5) still can't manipulate picture to solving problems; (b) Moderate self-regulated learning prospective elementary school teachers 1) can express mathematical ideas in the form of picture very well; 2) can determine and solve problems in the form of mathematics model clearly; 3) still can't provide a solution with rational reasons; 4) can evaluate mathematical ideas; and 5) can manipulate picture to solving problems but didn't understand well; and (c) High self-regulated learning prospective elementary school teachers 1) can express mathematical ideas in the form of picture very well; 2) can determine and solve problems in the form of mathematics model clearly; 3) still can't provide a solution with rational reasons; 4) can evaluate mathematical ideas very well; and 5) can manipulate picture to solving problems very well.

3.2. Discussion

Based on descriptive data, nine prospective elementary school teachers were interviewed regarding their answers. Several prospective elementary school teachers are at the moderate level of self-regulated learning but have higher mathematical communication ability scores than prospective elementary school teachers who are at the high level of self-regulated learning. This means that the level of self-regulated learning does not affect mathematical communication ability. This is in line with research that conducted by Meri et al. (2022) stated that self-regulated learning doesn't have significance effect on mathematical communication ability. Gunur et al. (2023) also stated that self-regulated learning just give 12.88% effect for mathematical communication ability. It is shown that self-regulated learning not always have significant effect for mathematical communication ability. Sulastri and Sofyan (2022) stated that even though prospective elementary school teachers have high self-regulated learning level, they still not have all of mathematical communication ability indicators.

Based on the study's results, it can be concluded that prospective elementary school teachers who have high self-regulated learning almost meet all indicators of mathematical communication skills. It's just that they have not been able to provide solutions with rational reasons. Their reasoning is not based on mathematical concepts because they have not understood the basic concepts of geometry clearly. This can happen because they have not understood the concept of geometry as a whole. Based on Sudia and Muhammad (2020) research results that students mathematical communication ability that have high self-regulated learning level meet all indicators such as problem representation in the form of images, express ideas verbally, explain concepts with symbols, and solve problems. Similarly as Maryati et al. (2022) research results that explain prospective teachers who have high level mathematical communication ability can express mathematical ideas verbally, writing or visual, evaluate mathematical ideas, and manipulate picture in solving problems. Also research from Purwati and Nugroho (2016) said that prospective teachers that have high level mathematical communication ability can describe mathematical ideas in various form. It can be seen from results section that prospective elementary school teachers that have high self-regulated learning level can manipulate picture very well, express mathematical ideas, determine mathematics model and evaluate mathematical ideas. Based on the results and comparisons, it can be concluded that prospective elementary school teachers who have a high level of self-regulated learning only meet four indicators, namely 1) expressing mathematical ideas in the form of pictures, graphs, or diagrams; 2) determining and solving problems that occur in the form of mathematical models; 3) evaluating mathematical ideas in the form of pictures, graphs, or diagrams; and 4) defining mathematical problems by manipulating pictures or graphs.

Moderate self-regulated learning prospective elementary school teachers meet all mathematical communication ability indicators. Same as high self-regulated learning prospective teachers, they just can't provide a solution with rational reasons, however they not fully understand about geometry concepts when they manipulate picture to solving problems. Same as Turmuzi et al. (2021) results that shows prospective teachers can't solve problems because the lack of their knowledge about geometry concepts, so they can't solve the problems very well. There are some mistakes that prospective elementary school teachers made when providing mathematical ideas. Zahri et al. (2021) also said that prospective teachers in moderate mathematical communication ability have three characteristics in explain facts, concepts, operations, procedures and mathematical principles: 1) accurately; 2) fluently; and 3) systematically. However, they can't explain concepts completely because the lack of understanding concepts. The average of prospective elementary school teachers in moderate self-regulated learning can express mathematical ideas, manipulate picture to solving problems, and using various form to determine mathematics models. Different from Putri et al. (2019) research results that show prospective teachers still can't express mathematical ideas, manipulate picture to solving problems, and using various form to determine mathematics models. That can be happen because they not fully understand about mathematical concepts.

Low self-regulated learning prospective elementary school teachers just meet one indicator, which is determine and solve problems in the form of mathematics model. Different from research that conducted by Sudia and Muhammad (2020), prospective teachers can't give mathematics model accurately and precisely. However, they can express mathematical ideas using visual representation, find the relationship between concepts and can solve the problems. Different from our results that prospective elementary school teachers still can't express mathematical ideas in the form of pictures very well, can't manipulate picture to solving problems, and can't evaluate mathematical ideas. Purwati and Nugroho (2016) find that prospective teachers who have low mathematical communication ability still can't connect one to another concepts, express mathematical ideas, and manipulate picture to solving problems.

Based on the research results, it can be concluded that several factors cause prospective elementary school teachers not to have good mathematical communication skills: 1) lack of knowledge about geometric concepts, 2) lack of focus in class, and 3) lack of interest in studying mathematics. In line with Radiusman and Simanjuntak (2021) on their research said that there are some factors that prospective teachers made an error when solving mathematics problems, which is 1) the lack of understanding geometry concepts; 2) rarely working on geometry problems; and 3) confuse in solving geometry problems. Then, Angraini (2019) state that prospective teachers who are not fullfill mathematical communication ability indicators don't know the basic concepts of the material, because that they can't catch up the next material that have been taught by lecturers. Besides that, prospective teachers still don't have motivation to learn independently, which means that low self-regulation make them not understand the materials properly. So, it makes them to not fullfill all of the mathematical communication ability indicators.

4. CONCLUSION

The conclusion of this study shows that the level of self-regulated learning does not fully affect mathematical communication skills. Prospective elementary school teachers with high self-regulated learning almost meet all indicators, but they still cannot provide solutions with rational reasons. Then, prospective elementary school teachers with moderate self-regulated learning meet three indicators: they still cannot give the solutions rational reasons, and they do not fully understand when manipulating images to solve problems. Finally, prospective elementary school teachers with low self-regulated learning can determine and solve problems using mathematical models. Several factors make prospective elementary school teachers unable to have good mathematical communication skills: 1) lack of knowledge of basic geometry concepts; 2) lack of motivation to learn independently; 3) inability to manage what to learn; and 4) inability to evaluate their mistakes.

Some recommendation from us is to analyse more about mathematical communication ability in prospective elementary school teachers. To makes prospective elementary school teachers have a good mathematical communication ability, the class should be more interested. This thing is important because they will teach basic mathematics for elementary school students.

Acknowledgments

The authors would like to thank the LPDP Kemdikbud Indonesia for funding us to do his research through Beasiswa Pendidikan Indonesia. Also we'd like to thanks to Universitas Pendidikan Indonesia and IKIP Siliwangi for letting us to do this research. And last for all prospective elementary school teachers that participated in this research.

Declarations

Author Contribution	: MGR: Conceptualization, Visualization, Writing - original draft, and Writing - review & editing; W: Formal analysis, Methodology, and Writing - review & editing; TH: Supervision, and Validation; N: Formal analysis, Methodology, and Writing - review & editing.
Funding Statement	: This research was funded by the LPDP Kemdikbud Indonesia for funding us to do his research through Beasiswa Pendidikan Indonesia.
Conflict of Interest	: The authors declare no conflict of interest.
Additional Information	: Additional information is available for this paper.

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