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Analysis of Self-Regulated Learning at Each Level of Mathematical Creative Thinking Skill

Análise da Aprendizagem Autorregulada em Cada Nível de Habilidade de Pensamento Criativo Matemático

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Abstract

Most individuals do not understand creative mathematical thinking only as a cognitive factor, whereas creative mathematical thinking plays a role in affective factors. Self-regulated learning is considered an affective factor that influences mathematical creative thinking skill. The purpose of this study determines the effect of SRL on mathematical creative thinking skill and analyzes in detail the components of SRL at each level of creative mathematical thinking. This study uses an explanatory sequential combination research design. The study population was high school students at SMAN 3 Klaten. The sampling technique used in this study is simple random sampling. The research sample measured mathematical creative thinking ability (Y) as a dependent variable, and SRL consists of three components, namely metacognition (X_1), motivation (X_2), and behavioristic (X_3). At the same time, the research subject selection technique is purposive sampling. The researcher chose to divide students' mathematical creative thinking skills into three levels: high, medium, low, where in each level was selected three research subjects. SRL has a positive effect on the ability to think mathematically creative by 85.4%. Metacognitive has the strongest influence on mathematical creative thinking skills. The SRL component has a role in every aspect of creative mathematical thinking consisting of fluency, flexibility, elaboration, and originality. Therefore, for improving mathematical creative thinking skills, students should be given learning based on SRL.

Keywords: Behavioristic. Mathematical creative thinking. Metacognitive. Motivation. Self-regulated learning

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Resumo

A maioria dos indivíduos entende o pensamento criativo matemático não apenas como um fator cognitivo, mas também como um fator afetivo. A aprendizagem autorregulada (SRL) é considerada um fator afetivo que influencia a capacidade de pensamento criativo matemático. O objetivo deste estudo é determinar o efeito do SRL na capacidade de pensamento criativo matemático e analisar em detalhes os componentes do SRL em cada nível do pensamento criativo matemático a partir de um projeto de pesquisa de combinação sequencial explicativa. A população do estudo foi composta por alunos do ensino médio da SMAN 3 Klaten. A técnica de amostragem usada neste estudo é a amostragem aleatória simples. A amostra da pesquisa mediu a capacidade de pensamento criativo matemático (Y) como uma variável dependente e o SRL consiste em três componentes, a saber, metacognitivo (X_1), motivação (X_2) e comportamental (X_3), sendo que a técnica de seleção de sujeitos de pesquisa é a amostragem proposital. Metacognitivo tem a maior influência nas habilidades de pensamento criativo matemático. A pesquisadora optou por dividir as habilidades de pensamento criativo matemático dos alunos em três níveis, a saber, alto, médio e baixo, de forma que, para cada nível, foram selecionados três sujeitos de pesquisa. SRL tem um efeito positivo de 85,4% sobre a capacidade de pensar criativo matematicamente. O componente SRL tem uma função em todos os aspectos do pensamento criativo matemático, consistindo em: fluência, flexibilidade, elaboração e originalidade. Portanto, para melhorar as habilidades de pensamento criativo matemático, os alunos devem receber um aprendizado baseado no SRL.

Palavras-chave: Aprendizagem Autorregulada. Behaviorismo. Metacognitivo. Motivação. Pensamento Criativo Matemático.

1 Introduction

Mathematics is a branch of science that underlies the development of modern technology. One of the goals of mathematics as a field of study taught at school is to develop creative activities. Creative activities are activities that are directed to encourage student creativity. Mathematical creativity at the school level does not expect extraordinary creative work, but it can offer new insights into mathematical problems appropriate for students (SHRIKI, 2010). Creativity is related to creative thinking because creativity is the result of the creative thinking process. Therefore, Chamberlin and Moon (2005) define the mathematical creative thinking skill as an unusual ability to produce solutions that are applied to mathematical problems.

The mathematical creative thinking skill as a high-level ability is still a serious concern. Bart, Hokanson, Sahin, and Abdelsamea (2015) state that creativity is an important ability, especially in education. Students are expected to develop creative mathematical thinking skills to solve problems requiring higher-order thinking abilities. Advances in technology impact increasingly complex problems that must be faced, therefore according to Puspitasari, In'am, and Syaifuddin (2018), students equipped with mathematical creative thinking ability cannot only solve school problems. They can also solve problems encountered in everyday life.

Understanding the mathematical creative thinking skill is still considered low. Most people do not understand that creative mathematical thinking appears as a cognitive and

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affective factor (AKGUL; KAHVECI, 2016). The creative thinking skill as a cognitive factor is prevalent by providing tests that measure fluency, flexibility, originality, elaboration, or divergent thinking tests. However, Runco and Acar (2012) state that divergent thinking tests are social and psychological factors and how they are related to creative potential. So that cognitive factors are not the only factors that influence the development of the mathematical creative thinking ability.

Several factors, including self-efficacy, mathematical achievement, and metacognition, significantly influence students' creative thinking abilities (AKGÜL; KAHVECI, 2017). One factor affecting mathematical creative thinking ability is metacognition (FAUZI *et al.*, 2019). Metacognition plays an important role in effective self-regulation of learning, such that metacognitive development can increase flexibility in solving complex problems (HARGROVE; NIETFELD, 2015). In addition to metacognition, motivation also positively affects mathematical creative thinking ability (ERBAS; BAS, 2015). When individuals exhibit intrinsic solid motivation at work, they are more likely to show high creativity (EISENBERGER; SHANOCK, 2003). Similarly, learning motivation is also positively related to creativity in solving unique mathematical problems (BISHARA, 2016).

On the other hand, Lee and Erdogan (2007) state that learning environments are essential factors in students' attitudes toward science and creativity. The learning environment encourages students to participate in open investigations actively and explores various techniques and solutions that can have a significant impact on students' critical and creative thinking ability (KWAN; WONG, 2014; TANDISERU, 2015; TUNCA, 2015). Creative students are students who successfully control and monitor their learning environment (STERNBERG; GRIGORENKO; SINGER, 2004). An environment that provides much mental stress will significantly inhibit the brain's performance, so students will find it difficult to absorb information conveyed by the teacher during the teaching and learning process. Therefore, it becomes crucial for teachers to create comfortable physical and mental conditions and support students in learning activities to develop mathematical creative thinking ability.

Motivation, metacognition, and learning environments based on the description above affect the mathematical creative thinking ability. Motivation, metacognition, and learning environments are the components forming self-regulated learning (SRL) (ZIMMERMAN, 1989). According to Hadwin and Oshige (2011), SRL can control, organize, plan, direct, and monitor behavior to achieve a specific goal by using certain strategies and involves metacognitive, motivational, and behavioristic aspects. Cleary and Kitsantas (2017) state that SRL has a strong repertoire of cognitive strategies and regulations, including seeking help,

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elaboration, environmental structuring, and planning. SRL positively influences mathematics achievement (FAST *et al.*, 2010; ALTUN; ERDEN, 2013). Therefore students can develop mathematical creative thinking ability through SRL learning (IVCEVIC; NUSBAUM, 2017; RUBENSTEIN *et al.*, 2018).

Khuziakhmetov and Gorev (2017) state that the low level of research on mathematics learning theory and methods has not considered all teaching concepts to develop creative thinking ability. Therefore, this study seeks to determine the effect of SRL on mathematically creative thinking. This research is expected to contribute to implementing learning strategies to develop mathematical creative thinking skills through the so-called method in detail the components of SRL at each level of creative mathematical thinking. This research identifies the components of SRL that can bring up aspects of creative mathematical thinking consisting of fluency, flexibility, elaboration, and originality.

2 Methods

Explanatory sequential design is a combination method that is used in this study. The explanatory sequential design begins with quantitative data collection, which provides an overview of the research problem followed by qualitative data collection to help explain or elaborate quantitative results. The use of explanatory sequential design begins with testing the effect of SRL components on mathematical thinking ability, then continues with SRL component analysis at each level of the mathematical creative thinking ability.

Figure 1 shows the design used in this study. This study applies problem-based learning (PBL) to bring out students' mathematical creative thinking ability. In line with Birgili (2015), PBL is one of the helpful tools for the development of creative ability. PBL syntax used in this study consists of: (1) problem orientation; (2) organize students to understand the problem; (3) assisting independent and group investigations; (4) develop and present a problem-solving process; and (5) analyze and evaluate problem-solving processes.

The population of this study was students of high school class XI high school at SMA N 3 Klaten. The research sample consisted of 36 students selected through a simple random sampling technique. This sampling technique provides an equal opportunity for each member of the population to become a research sample. The research sample measured mathematical creative thinking ability and SRL. Mathematical creative thinking skill (Y) as the dependent variable was measured using a mathematical creative thinking test (TKBM). Data analysis of the dependent and control variables uses multiple regression analysis to determine the effect of

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SRL components on mathematical creative thinking ability.

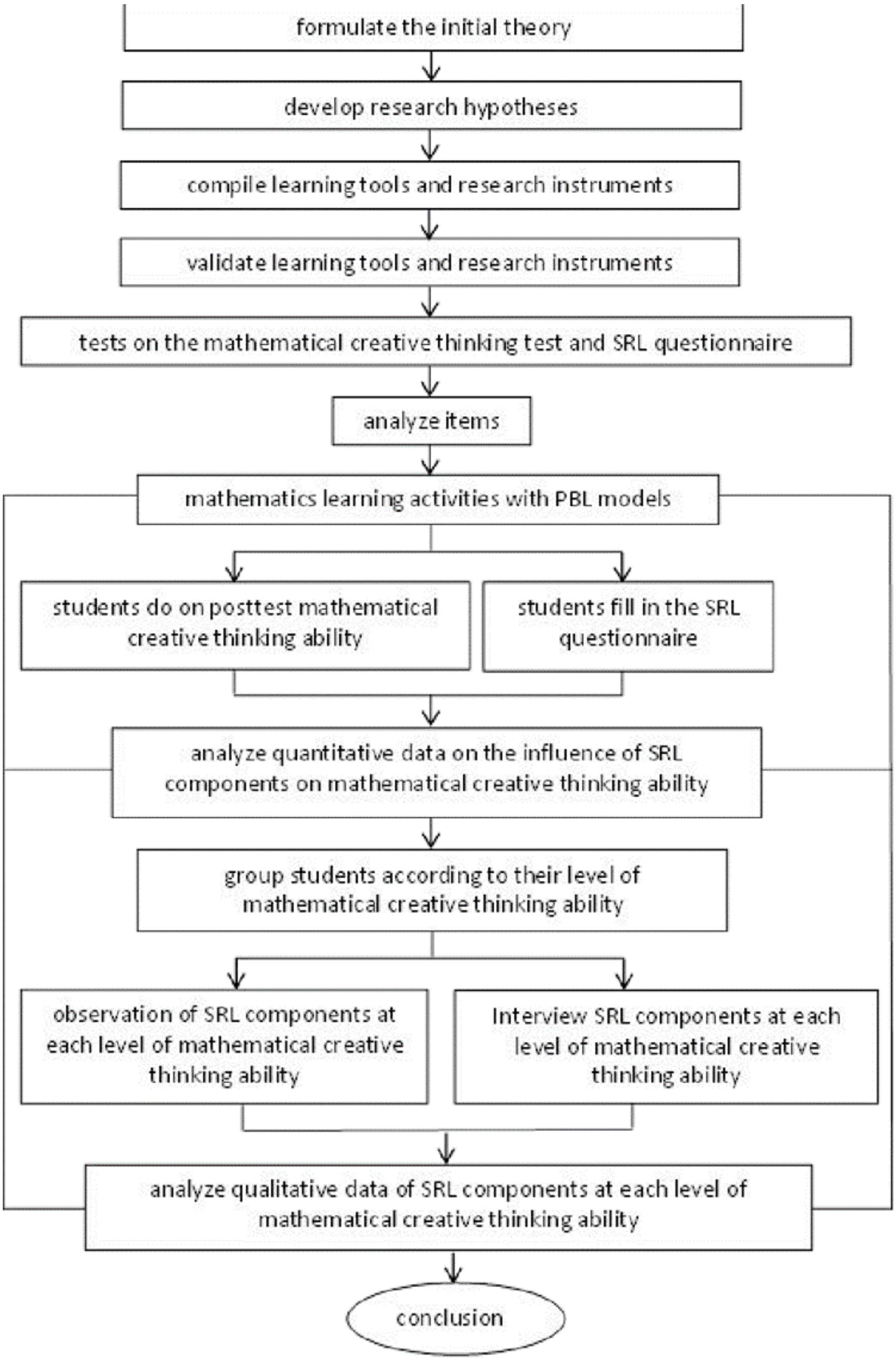

Figure 1 - Research design
Source: The Researchs (2017)

According to Pehkonen (1997), Haylock (1997), and Silver (1997), Sak and Maker (2006), Scott, Leritz and Mumford (2004), Kim, Cho and Ahn (2003), mathematical creative thinking ability tests are measured based on aspects of fluency, flexibility, originality, and elaboration. Fluency is assessed according to the number of correct answers to a problem.

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Flexibility is judged according to the number of strategies used to solve a problem. Originality is judged based on the uniqueness of the correct answer to a problem. Elaboration is assessed based on a detailed and coherent process of understanding the problem using appropriate and representative mathematical concepts. Based on the identification of aspects of mathematical creative thinking ability, Table 1 shows the grading rubric of the mathematical creative thinking test.

Table 1- Rubric assessment test mathematical creative thinking ability

aspects of creative mathematical thinking	Score		
	0	1	2
Originality	If there are 5% or more students who answer correctly with the same solution.	If there are 2% to 4.99% of students who answer correctly with same solution.	If there are less than 2% of students who answer correctly with the same solution.
Flexibility	If students cannot solve problems with any problem-solving strategy	If students can determine problem-solving strategies even though the results are not quite right	If students can solve problems with any solving strategy and produce the right solution.
Elaboration	If students cannot explain problem-solving in detail and coherently and do not use appropriate mathematical concepts, representations, terms, or notations	If students can only explain problem-solving in detail and coherently but do not use appropriate mathematical concepts, representations, terms, or notations	If students can explain problem-solving in detail and coherently and use appropriate mathematical concepts, representations, terms, or notations.
Fluency	Students can only determine one correct answer.	Students can determine several possible correct answers.	Students can determine all possible correct answers.

Source: Pehkonen (1997); Silver (1997); Sak and Maker (2006); Scott, Leritz and Mumford (2004); Kim, Cho and Ahn (2003)

The SRL analyzed in this study involves three components, namely, metacognition, motivation, and behavior (SCHUNK; ZIMMERMAN, 2012). The three components, namely metacognition (X_1), motivation (X_2), and behavior (X_3), are considered control variables measured by a psychological scale. Each SRL component consists of several sub-components. Metacognitive consists of sub-components as follows: planning, goal setting, organizing, self-monitoring, and self-evaluating. Motivation consists of sub-components as follows: self-efficacy, attribution, goal orientation, intrinsic motivation. Behavioristic consists of sub-components as follows: seeking information, environmental structuring, seeking peer assistance, seeking teacher assistance.

The technique for selecting research subjects in qualitative data collection is purposive

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sampling. Purposive sampling is where researchers intentionally select individuals to study and understand central phenomena (CRESWELL, 2015). Taking the subject of this study is based on the level of mathematical creative thinking ability. The level of student's creative thinking ability is based on mathematical creative thinking test scores. Classification of creative mathematical thinking is obtained from the ranking of the highest to lowest scores. Students classified as high mathematical creative thinking ability levels are included in 27% of the highest test scores, while students who are classified as low creative thinking levels are at 27% the lowest test scores (SUDIJONO, 2009). Students who are not in the category of high and low creative thinking skills are medium-level students.

Each level of mathematical creative thinking ability was chosen as the research subject. The selection of research subjects aims to ensure the credibility of the participants and the wealth of information that they can share with researchers. Furthermore, data collection on the research subjects through interviews, observations, and documents. Qualitative data analysis in this study refers to the stages of Creswell (2015) consisting of: (1) preparing and organizing data for analysis, (2) exploring and coding data, (3) coding to build descriptions and themes, (4) presenting and reporting qualitative findings, (5) interpreting findings, and (6) validating the accuracy of the findings.

3 Results

3.1 The Effect of SRL on the Mathematical Creative Thinking Skill

This study uses a regression test to determine metacognitive, motivational, and behavioristic on mathematical creative thinking ability. The following table shows the results of the linearity test with SPSS. Based on Table 2, the significance value is 0,000 < 0,05. It shows that the variable Y can be predicted by variables X_1, X_2, dan X_3. A linear regression model between SRL components (metacognitive, motivational, and behavioristic) with mathematical creative thinking ability is shown in table 3 below.

Table 2- Linearity test

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	4466.526	3	1488.842	65.762	.000[a]
Residual	724.474	32	22.640		
Total	5191.000	35			

Source: metacognitive scores (X_1), motivational scores (X_2), behavioristic scores (X_3) and mathematical creative thinking ability scores (Y)

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Based on Table 3, values of $a = -6{,}918$ and $b_1 = 0{,}831, b_2 = 0{,}117$, and $b_3 = 0{,}099$ so the regression equation is $Y = -6{,}918 + 0{,}831\ X_1 + 0{,}117\ X_2 + +0{,}099 X_3$. Variable of X_1, X_2, X_3, and Y have a linear relationship, so X_1, X_2, dan X_3 affect the Y variable. Therefore the regression equation applies. Based on the coefficient of the variable X_1, X_2, dan X_3, it can be seen that the variable has the highest coefficient value and the variable X_1 and X_2has the lowest coefficient value. Based on the significant value in Table 3, the metacognitive component has a significant effect on mathematical creative thinking ability because its significance value is $0{,}000 < 0{,}05$.

Table 3- Linear regression model

Model	B	Std. Error	Beta	t	Sign	Tolerance	VIF
Constant	-6.918	5.528		-1.252	.220		
X1 (metacognition)	.831	.173	.733	4.809	.000	.196	5.090
X2(motivation)	.117	.201	.101	.585	.563	.152	6.579
X3(behavioristic)	.099	.113	.117	.878	.386	.257	3.893

Source: metacognitive scores (X_1), motivational scores (X_2), and behavioristic scores (X_3) on mathematical creative thinking ability scores (Y), 2017

The magnitude of the influence of variables stated by the X_1, X_2, X_3, and Y coefficient of determination presented in Table 4. Based on Table 4, metacognition, motivation, and behavioristic have a positive effect on mathematical creative thinking ability by 85.4%. Other factors influence the remaining 14.6%. The components of SRL that most influence the mathematical creative thinking skill in more detail will be decomposed from the results of qualitative research as follows.

3.2 Analyzes Components of SRL at Each Level of Mathematical Creative Thinking Ability

Three research subjects chose each level of mathematical creative thinking ability for further research on SRL components. The nine research subjects were observed and interviewed related to SRL components attached to each research subject. Groups with low creative thinking levels are called SR subjects. Groups with medium creative thinking levels are called SS, and groups with high mathematical creative thinking levels are called ST subjects.

3.2.1 High Mathematical Creative Thinking Ability Levels

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The steps of ST subjects completing mathematical creative thinking test questions based on interviews and observations are as follows. ST subjects try to understand the problem to determine strategies that can be used to solve these problems. Figure 2 below shows how ST subjects try to understand the problem. ST subjects have an elaboration aspect in which they can understand the problem in detail. Figure 2 shows that ST subjects write in detail all the problem components, scale the graph based on the problem description, and write the components that would be sought from the problem. Therefore, ST subjects can plan the strategies to solve the problem and determine the problem's objectives.

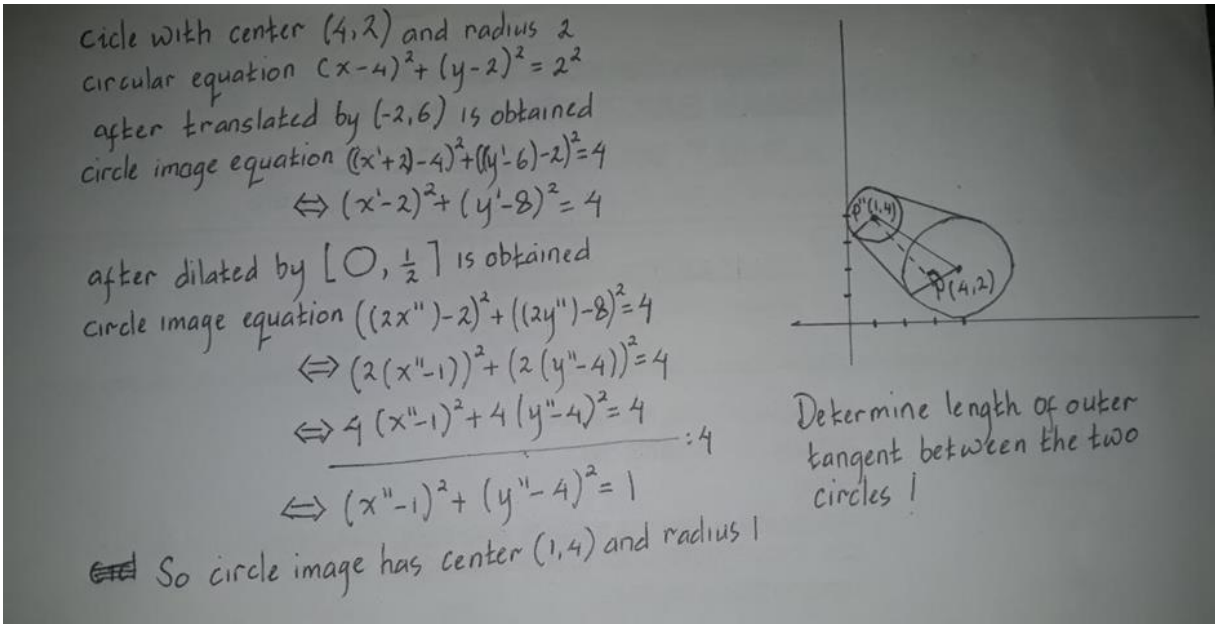

Figure 2 - Display of ST subjects in planning problem solutions and understanding the purpose of problems
Source: Answer sheet from student (2017)

ST subjects have the flexibility aspect so that they can determine several strategies to solve the problem. Figure 3 below shows the ST subjects resolving the problem using several resolution strategies.

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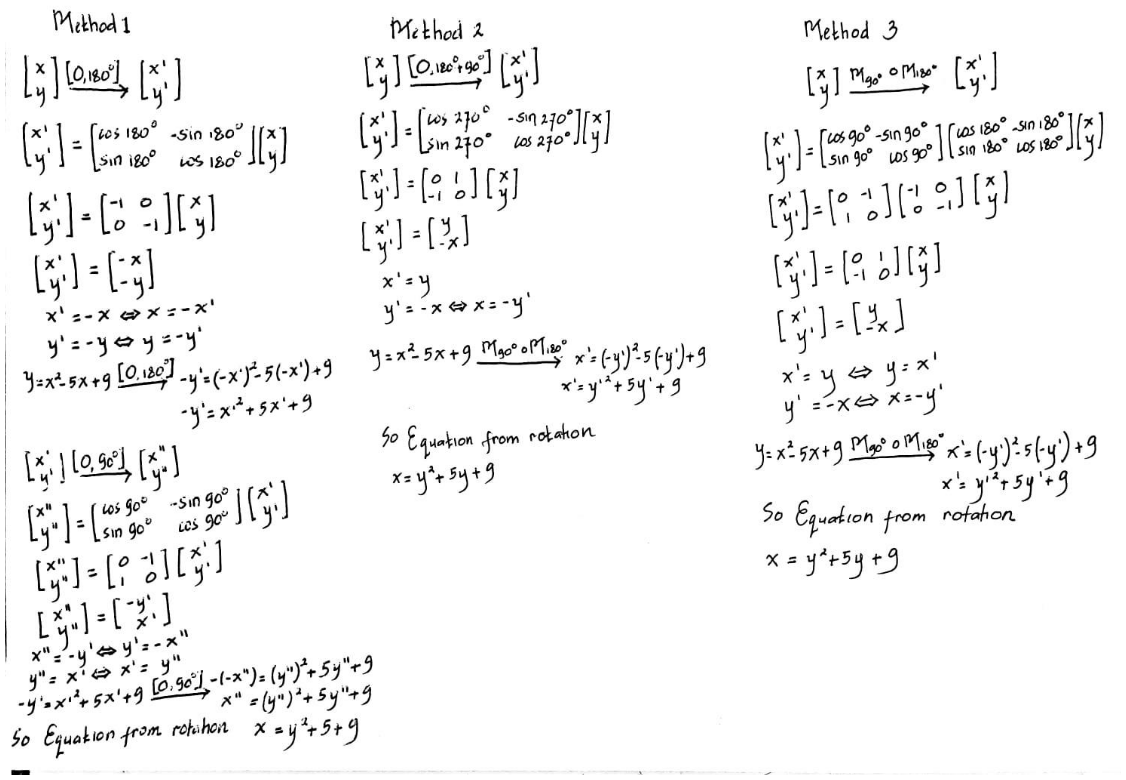

Figure 3- flexibility of ST subjects in finding solutions problems with several solving strategies
Source: Answer sheet from student (2017)

According to the interview results, solving the problem using several resolution strategies monitor again whether the results obtained are correct. The following are excerpts from interviews with them.

Teacher: What is the purpose of using several problem-solving strategies?
ST Subject: To be able to convince me that my calculation results are correct.
Teacher: What if the results you get are different?
ST Subject: I will monitor each sequence of steps to solve the problem
*(*Dialogue between teacher and student, 2017)

The ST subject has a fluency aspect in solving mathematical problems so that they can solve various problems. The following are the results of interviews with ST subjects.

Teacher: Are you able to identify mistakes made when you solve problems?
ST Subject: Yes, I noticed the mistakes I made after working on the problem. When I'm curious about the results that I will get, I go back to working on those questions to predict the score that I will get.
Teacher: What changes do you apply when you realize the mistakes you are making?
ST Subject: I will remember it and try not to repeat that mistake again.
*(*Dialogue between teacher and student, 2017)

The above interview results indicate that ST subjects are aware of the mistakes they make in solving mathematical problems. ST subjects estimate their scores after returning to work on these questions to say that ST subjects can evaluate themselves.

ST subjects can achieve the highest aspects of mathematical creative thinking ability,

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namely, originality. It is because ST subjects solve problems using unique strategies, different from others. ST subjects can determine the length of the outer tangent between two circles by first sketching the circle with the center (2,4) and radius 4 and the shadow of the circle from the result of geometric transformation (translation continues with dilation). ST subjects can analyze through sketches that tangents outside the circle form a right angle to the difference between the radii of the two circles. ST subjects determine the radius of the two circles through the equations of the two circles because between the tangent outside the circle, the radius of the circle, and the distance of the two center circles form a right triangle. Then, ST subjects apply the Pythagorean theorem to determine the tangent length of the external alliance circle.

The steps of ST subjects in determining the length of the outer tangent between two circles are originality in solving mathematical problems, because they can explore unique ideas where many students are not able to reach this understanding. Originality in solving problems obtained by ST subjects is obtained through a long process and is influenced by various factors. The following are the results of interviews with ST subjects which indicate how ST subjects could obtain originality in solving mathematical problems.

Teacher: Why are you so interested in learning mathematics?
ST Subject: I like numeracy lessons.
Teacher: How do you manage your study time, especially in learning mathematics
ST Subject: I regularly schedule home study activities at night before going to bed and in the morning before leaving for school. I study mathematics when there is a mathematic class scheduled for the next day, when there are no tasks or mathematic assignments.
Teacher: If the mathematic teacher does not provide homework, what do you learn at home?
ST Subject: I try to work on mathematic problems that have never been discussed at school, because I feel challenged to solve problems that have quite serious difficulties. I even exchanged questions with my friends at different schools.
Teacher: What if you have difficulty in solving these mathematic problems?
ST Subject: I try to find solutions from various books I have, search the internet, or even ask people I consider to be experts in the field, such as teachers, peers, etc.
Teacher: When you are going to take a mathematic test, what preparation do you do?
ST subject: I prepare myself by re-studying the mathematical material discussed in class, opening notes that the teacher has given to be re-studied.
Teacher: How do you create a comfortable learning environment?
ST Subject: I try to find a comfortable place when studying, try not to hold my cellphone while studying, and keep away from all things that interfere with my concentration in learning.
Teacher: How can you learn to be easily understood and remembered?
*ST Subject: I rework the questions which I learned until I understand the steps correctly (*Dialogue between teacher and student, 2017)

Based on the description above, ST subjects have high motivation in learning mathematics. ST subjects try to explore their ability by searching for mathematic problems and working on them without instructions from the teacher. Therefore ST subjects can find originality in solving mathematical problems. The more difficulties they find, the higher the ability they get. ST subjects also have a high behavior component. It can be seen from the way

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of learning that ST subjects have by trying to create a comfortable learning atmosphere, relearning material that the teacher gave them, and trying to ask for help if there are difficulties in solving mathematical problems.

3.2.2 Medium Mathematical Creative Thinking Levels

The aspects of mathematical creative thinking ability successfully achieved by SS subjects were elaboration, flexibility, and fluency. The aspect of originality has not been achieved by SS subjects properly. The following research results can explain why SS subjects have not reached the highest aspects of mathematical creative thinking ability. Figure 4 below shows how SS subjects try to understand the problem to design steps to solve the problem. SS subjects have aspects of elaboration which can specify in detail the problem. Figure 4 shows that the SS subjects write in detail all the problem components, scale the graph based on the problem description, and write the components that would be sought from the problem. Therefore the SS subjects can plan strategies to solve the problem and determine the problem objectives.

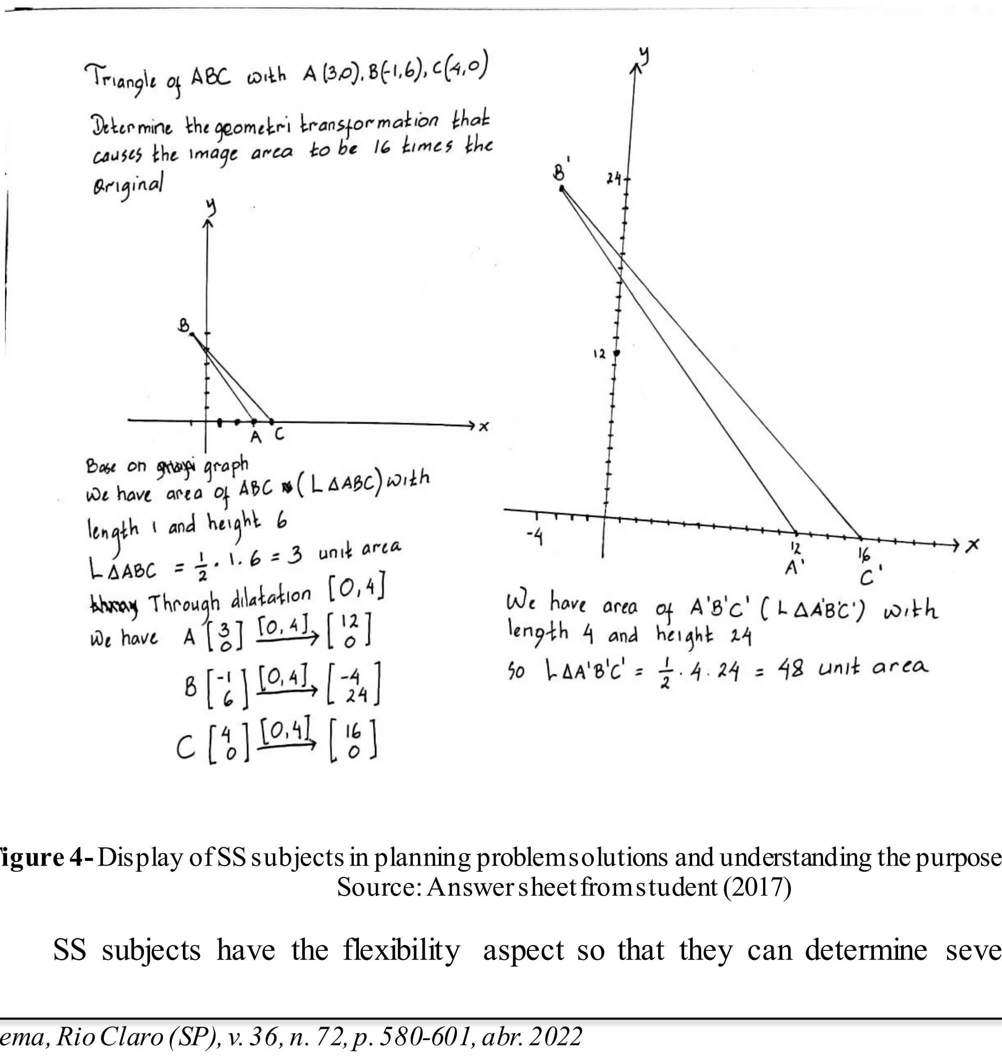

Figure 4 - Display of SS subjects in planning problem solutions and understanding the purpose of problems
Source: Answer sheet from student (2017)

SS subjects have the flexibility aspect so that they can determine several problem-

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solving strategies. Figure 5 below shows how SS subjects solved the problem using several resolution strategies.

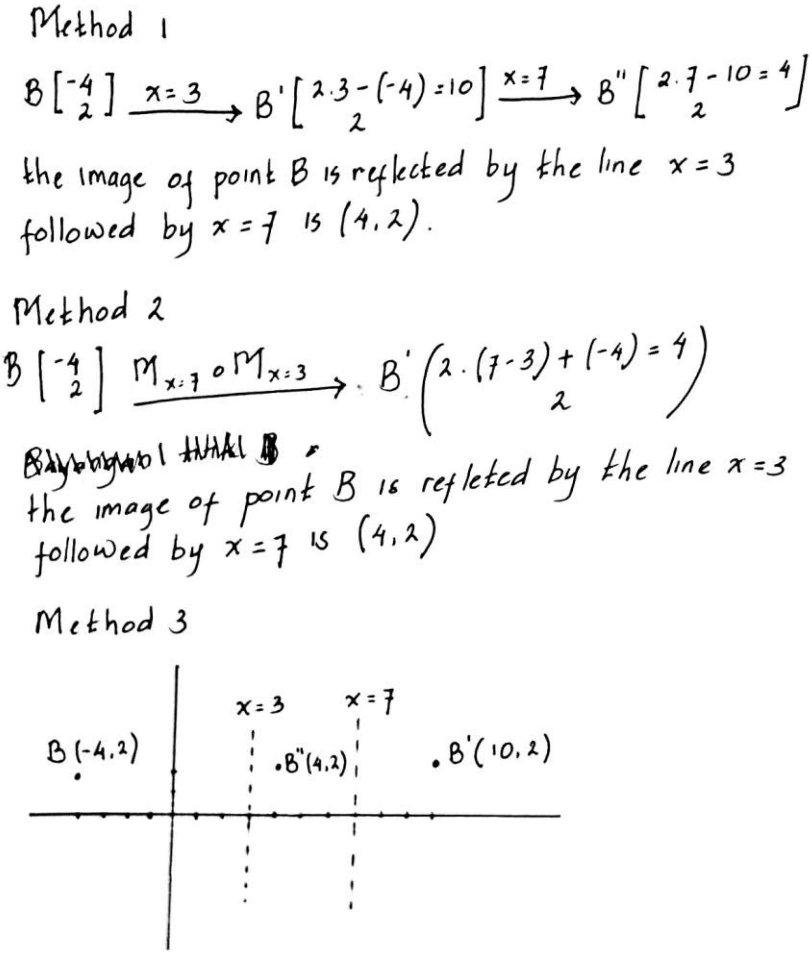

Figure 5- flexibility of SS subjects in finding solutions problems with several solving strategies
Source: Answer sheet from student (2017)

Following are the results of interviews with SS subjects in using various strategies in solving problems.

Teacher: What is the purpose of using several strategies to solve the problem?
SS subject: I became convinced that my calculation results were correct.
Teacher: What if the results you get are different?
*SS subject: I will check every step of the problem-solving if there are calculations that are still wrong. (*Dialogue between teacher and student, 2017)

According to the interviews with SS subjects, the goal to solve the problem by using several strategies is to check whether the results obtained are correct. SS subjects have a fluency aspect in solving mathematical problems, so they solve problems with some answers. The following are the results of interviews with SS subjects:

Teacher: What are you doing to identify mistakes made when you solve problems?

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SS subject: I am aware of the calculation errors. I was able to predict questions so I can solve them correctly.
Teacher: What changes when you realize the mistakes you are making?
SS Subject: I can evaluate my ability in learning mathematics
*(*Dialogue between teacher and student, 2017)

The above interview results indicate that SS subjects are aware of the mistakes they made in solving mathematical problems. SS subjects predicted the scores they would get after returning to work on these questions, so. it could be said that SS subjects were able to evaluate the results of their work.

SS subjects are unable to reach the aspect of originality. The following interview can give reasons why SS subjects can't reach the aspect of originality.

Teacher: Why are you so interested in learning mathematics?
SS subject: I prefer numeracy rather than memorization.
Teacher: How do you manage your study time, especially in learning mathematics?
SS subject: I learned to do mathematic problems if there were assignments from the teacher.
Teacher: If the mathematic teacher does not provide homework, do you try to do the mathematic problems in the book?
SS subject: Yes, sometimes I try to do the questions in the book. But I often have difficulty working on problems, so I stop working on them.
Teacher: What do you do if you have difficulties in solving this math problem?
SS Subject: If I have trouble at home, then I no longer work on the problem. But if I experience difficulties at school, then I will try to ask the teacher or a friend.
Teacher: Do you not feel challenged to work on problems from various book sources other than the manual you use every day?
SS Subject: I still have many difficulties working on problems in the manual that I use every day, so I never try to look for questions from other sources.
*(*Dialogue between teacher and student, 2017)

Based on the description above, SS subjects can say that SS subjects' learning motivation is still low. SS subjects can explore their ability to solve mathematical problems. It can be seen from the attitude of SS subjects who give up easily when they have difficulties solving problems. SS subjects do not extract to solve problems with a high level of difficulty, so SS subjects cannot reach the originality aspect to solve mathematical problems.

3.2.3 Low Mathematical Creative Thinking Levels

SR subjects based on test results cannot reach aspects of mathematical creative thinking ability. SR subjects can only mention one solution of a problem that has more than one solution. SR subjects cannot check the solutions obtained by using different strategies. The following interview excerpts and observations on the SR subjects explain why SR subjects did not try to recheck the solutions obtained.

Teacher: Have you ever checked your calculation results so that you are sure of the answers you

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> *get?*
> *SR Subject: I have never checked my answers.*
> *Teacher: Can you identify mistakes made when you solve problems?*
> *SR Subject: I have never re-identified the many errors in solving mathematical problems. Therefore I cannot predict the score to be obtained.*
> *The interview excerpt above indicates that SS subjects cannot evaluate themselves to solve mathematical problems.*
> *Teacher: Do you like mathematic?*
> *SR Subject: I don't like mathematics because my mathematic ability is low.*
> *Teacher: How do you manage your study time at home, especially in learning mathematics*
> *SR Subject: I rarely study at home. I study if there is an assignment. I prefer working at school because I can borrow a friend's job.*
> *Teacher: Are you doing your teacher's work just copying a friend's work or trying to understand the completion strategy?*
> *SR Subjects: Some solutions are just copied. Some are trying to understand their resolution strategies. (*Dialogue between teacher and student, 2017)

Interview quotes indicate that SR subjects have no motivation in learning mathematics. Based on interviews, observations, and results of mathematical creative thinking tests on SR subjects, SR subjects do not yet have SRL components in mathematics learning.

4 Discussion

SRL components consisting of metacognition, motivation, and behavior positively affect thinking creatively mathematically by 85.4%, and other factors influence the remaining 14.6%. Metacognition is one of the most influential components of SRL compared to other components. Creative problem-solving can be enhanced by educational interventions that support the instruction and regulation of metacognitive strategies (HARGROVE; NIETFELD, 2015). Safitri and Kuntjoro (2018) also state that metacognitive learning can motivate students to increase their learning awareness, provide opportunities for understanding and solving problems, and develop creative thinking skills. Therefore, the mathematical creative thinking ability and motivation have a robust positive correlation (AL-ZU'BI; OMAR-FAUZEE; KAUR, 2017). Creative thinking can be developed by creative teachers who help shape creative situations, support student initiatives and make room for new and original ideas. Quantitative research results indicate that only metacognitive has a significant influence on mathematical creative thinking ability.

Students with high levels of creative mathematical thinking have aspects of creative mathematical thinking consisting of elaboration, flexibility, fluency, and originality. They have aspects of elaboration, where students can explain in detail and coherently in problem-solving. They also use appropriate mathematical concepts, representations, terms, or notations to

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understand the purpose of the problem and plan problem-solving strategies. They also have flexibility, where they can solve problems using more than two problem-solving strategies. Therefore, they can evaluate the results of their work by comparing the results obtained from several different settlement strategies. They have aspects of fluency, where students can solve various mathematical problems to monitor the results of their work.

Based on the description above, students with a high level of creative mathematical thinking in solving mathematical problems consist of planning a resolution strategy, determining the goal of problem-solving, evaluating the results, and monitoring the results obtained. The four steps are sub-components of metacognition. Schraw, Crippen, and Hartley (2006); Zimmerman (2008) state that metacognition is an important component of SRL. Metacognition emphasizes knowledge about monitoring and regulation of cognitive processes (DU TOIT; KOTZE, 2009). Boekaerts (1995) state metacognitive strategies as decisions made by students before, during, and after the learning process. It is in line with the results of research from metacognitive sub-components of students with high levels of creative mathematical thinking: planning a solution to the problem, determining the goal of problem-solving, evaluating the results, and monitoring the results obtained. Planning a settlement strategy is carried out by them before the problem-solving process. Students with high levels of mathematical creative thinking ability determine problem-solving and monitoring goals during the problem-solving process. At the end of the problem-solving process, they evaluate the results of problem-solving. A person needs to know and understand his cognition and monitor thought processes during problem-solving to become successful in solving problems.

Students with high levels of mathematical creative thinking ability have an aspect of originality, where students can solve problems using unique solving strategies. The aspect of originality is the highest in creative mathematical thinking. Therefore, the metacognitive component is needed to achieve it, and also motivation and behavior. The motivation of students with a high level of creative mathematical thinking in mathematical problem–solving is always optimistic in solving problems, feeling challenged to solve problems that require high-level thinking ability, and never giving up on solving difficult tasks. Strengthening the learning motivation also increases academic involvement and learning competence (RESCHLY; HUEBNER; APPLETON; ANTARAMIAN, 2008). The behavior of students with a high level of mathematical creative thinking ability can be seen from the way they are learning, in which they try to create a comfortable atmosphere for learning and keep away all things that can interfere with their concentration in learning. If they have difficulty working on mathematical problems, they will try to seek help from a teacher or friend and try to remember the material

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given by the teacher.

Students with medium levels of mathematical creative thinking ability have creative mathematical thinking: elaboration, flexibility, and fluency. They cannot reach the aspect of originality in solving mathematical problems. It can be caused because the motivation is still relatively low. They are interested in working on math problems, but they are quickly given up when faced with obstacles. They are also less interested in solving problems with a high degree of difficulty.

Students with a low level of mathematical creative thinking ability do not reach creative mathematical thinking because they do not have all the SRL components. They cannot reach the metacognitive component well. It is seen in solving mathematical problems to plan a solution to the strategy and determine problem-solving. However, they have not been able to evaluate and monitor the results obtained in solving problems. Metacognition support is increased in terms of self-regulation in general, compared with students taught in the same learning conditions without metacognitive support (KRAMARSKI; GUTMAN, 2006; KRAMARSKI; MIZRACHI, 2006). The motivation and behavior of students with low mathematical creative thinking ability levels are still low.

Zimmerman (1989) defines SRL as the degree to which students are metacognitive, motivated, and active in their learning. The Metacognition process consists of planning, goal-setting, organizing, monitoring, and evaluating. Motivation consists of self-motivation, perceptions of self-efficacy, personal attributes, and intrinsic task interest. Behavior consists of learning strategies, perseverance in seeking information and assistance, and creating a positive learning environment. According to Schraw, Crippen, and Hartley (2006), SRL consisted of three main components: cognition, metacognition, and motivation. Cognition includes the ability needed to encode, memorize, and remember information. Metacognition includes an ability that enables students to understand and monitor their cognitive processes. Motivation includes beliefs and attitudes that influence the use and development of cognitive and metacognitive abilities. Meanwhile, according to Baumeister and Heatherton (1996), Carver and Scheier (2011), Schnell *et al.* (2015), Wang, Ng, Liu and Ryan (2016), SRL is associated with behavioral control and goal-oriented. Students should have all components of SRL in order to be able to achieve all aspects of mathematical creative thinking ability.

Teachers carrying out learning activities are expected to apply SRL components so that students' mathematical creative thinking ability can be developed. Sun, Xie and Anderman (2018) state that SRL is effectively applied to the mathematics learning process. According to Ibrahim, Arshad, and Rosli (2015), learning by applying SRL can reach higher-level abilities.

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SRL encourages students to understand cognition and emotions about their situation to achieve the expected goals.

5. Conclusion

SRL has a positive effect on creative mathematical thinking by 85.4%, and other factors influence the remaining 14.6%. SRL in this study consists of three components, namely metacognition, motivation, and behavior. Metacognition has the most decisive influence on mathematical creative thinking ability compared to other components. The components of SRL encourage students to achieve aspects of creative mathematical thinking. The aspects of creative mathematical thinking consist of fluency, flexibility, elaboration, and originality.

Students based on mathematical creative thinking ability are divided into three categories: high, medium, and low levels. Each level has different components of SRL. The metacognition sub-component achieved by students with a high and medium level of creative mathematical thinking consists of planning, goal setting, organizing, self-monitoring, and self-evaluating. Simultaneously, students' metacognition at a low level of creative mathematical thinking has not yet reached self-monitoring and self-evaluation. Motivation owned by students with a high level of creative mathematical thinking consists of self-efficacy, attribution, goal orientation, intrinsic motivation.

Nevertheless, the motivation of students with medium creative thinking levels is still relatively low. It can be seen from several components of motivation that are not visible, namely self-motivation and intrinsic task interest. Behavioral sub-components of students at the level of creative mathematical thinking, seekinh information, environmental structuring, seeking peer assistance, seeking teacher assistance. On the other hand, students at the low mathematical creative thinking level have not SRL components in themselves.

6. Recommendation

The components of SRL have a role in achieving aspects of creative mathematical thinking. Therefore, by improving mathematical creative thinking ability, students should be given learning based on SRL. Even in a mass pandemic that requires students to do online learning independently, the teacher should develop the SRL component to achieve learning objectives.

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