Journal of Mathematics Education
Website: http://usnsj.id/index.php/JME
Email: pengelolajme@gmail.com
p-ISSN 2528-2468; e–ISSN 2528-2026

DOI: https://doi.org/10.31327/jme.v9i1.2158

CPS MODEL ON CREATIVE THINKING SKILLS IN MATHEMATICS PROBLEM SOLVING IN TERMS OF SELF-REGULATED LEARNING

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Article Info

Article history:

Received Mei 03, 2024
Revised Mei 17, 2024
Accepted June 01, 2024

Keywords:

Creative thinking skill
Creative Problem Solving

ABSTRACT

Creative thinking and problem solving skills are essential in facing the challenges of the 21st century. This study aims to (1) test the effectiveness of the contextual approach CPS model in improving creative thinking skills in mathematics problem solving and (2) describe creative thinking skills in mathematics problem solving in terms of Self Regulated Learning (SRL). This type of research is a mixed method research that combines quantitative and qualitative research methods sequentially. In this study, 6 research subjects were taken based on the level of SRL in class XI students of SMA N 5 Semarang. The results showed that (1) contextual approach CPS learning is effective in improving creative thinking ability in mathematics problem solving, and (2) research subjects with high SRL category were able to fulfill all indicators of creative thinking ability in mathematics problem solving, namely fluency, flexibility and novelty; research subjects with moderate SRL category only fulfilled two indicators of creative thinking ability in mathematics problem solving, namely fluency, and flexibility; research subjects with low SRL category were only able to fulfill the indicator of creative thinking ability in mathematics problem solving, namely fluency.

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How to Cite:

Hamid, E.M. ,Isnarto, Kharisudin, I. (2024). CPS Model on Creative Thigking Skills in Mathematics Problem Solving in Terms of Self-Regulated Learning. *JME:Journal of Mathematics Education*, 9(1), 69-82.

1. INTRODUCTION

Education in the era of globalization is characterized by the increasingly sophisticated development of Science and Technology (IPTEK) which has a rapid impact on the world of education (Jamun, 2018).The development of technology and information requires high intelligence, including skills in the aspect of mathematics. Mathematics is a subject that has an important role in the world of education and must be studied at every level of education.

Mastery of mathematics is very important with the development of Science and Technology (IPTEK) which is growing rapidly today (Wijayanto et al., 2021). Mathematical knowledge is considered very useful for students who want to follow higher-level learning to solve everyday life problems. Learning and developing mathematics can improve learners' abilities in creative, collaborative, communication and critical thinking. Therefore, math is very important to learn in today's modern era (Beswick & Fraser, 2019).

To be able to compete in today's world of education, students are required to have the ability to think. NCTM (2000) states that in the 21st century, learners need to develop problem solving, reasoning and proof, communication, connection and representation skills. In addition, Voogt & Roblin (2012) revealed that to develop relevant and high-quality products, 21st century competencies are considered important by most frameworks, such competencies include competencies in communication, collaboration, ICT skills, social or cultural competencies. Most frameworks also mention creativity, critical thinking, productivity and problem solving. The *Partnership for 21 st Century Skills* (2015) identifies 21st century skills as creativity and innovation, critical thinking and problem solving, communication and collaboration. These abilities are known as the 4Cs. Based on this, it can be concluded that the ability to think creatively and solve problems is very important in facing the challenges of the 21st century.

But in reality, the creative thinking ability of students in Indonesia is said to be still very low. According to The Global Creativity Index data, Indonesia is ranked 115 out of 139 countries for creativity (Florida et al., 2015). (Arista & Mahmudi, 2020) in their research showed that the results of students' creative thinking skills in solving PISA type questions showed that in addition to creative thinking skills, the problem solving skills of Indonesian students were also still relatively low.

Based on the results of observations regarding the activities of students in learning mathematics, researchers conducted initial tests to be more convincing regarding the problems that occurred in the classroom. The results of the initial test that researchers have carried out are presented in Table 1.1

Table 1.1 Preliminary Study Results

Class	Initial Average
XI-2	63, 10
XI-7	60, 15
Total average	61, 63

Based on Table 1.1, the preliminary study was conducted by giving an initial test of creative thinking ability in mathematical problem solving. In representatives of two classes XI SMA 5 Negeri Semarang. The results of the study showed that the average value of creative thinking skills in solving mathematical problems of students was still relatively poor. In addition to these problems, the results of interviews with one of the mathematics teachers of SMA Negeri 5 Semarang, showed that the ability of students in creative thinking is still not optimal. There are several possible causes of the low level of students' creative thinking ability due to the lack of understanding of basic concepts in students, students are more often given practice problems that have a single solution so that students are only oriented to the formulas that are often used in solving them, in addition to these problems, most students have background problems that cause students' learning motivation to decrease. Therefore, efforts need to be made to develop and improve both abilities. Creative thinking ability is related to the problem of problem solving ability.

Creative thinking skills are higher-level thinking skills (King et al., 2009). Creative thinking ability also refers to the ability to solve problems (Sitorus, 2020). Because creative thinking skills are an important aspect of problem solving and developing or finding ideas to solve problems (Yayuk et al., 2020). Problem solving is a level of intellectual activity that uses existing knowledge to find a solution to a problem (NCTM, 2000). Problem solving and problem posing can be used to develop mathematical creativity (Levav-waynberg & Leikin, 2012). In Silver (1997) research, it is argued that mathematics lessons centered on problem-generating questions and activities related to problem solving and problem posing can help learners develop more creative thinking in mathematics. Through the use of these tasks and activities, teachers can increase the capacity of their learners in relation to the basic qualities of creativity, namely fluency, flexibility and novelty.

One aspect that affects the ability of students' thinking to express themselves creatively when solving mathematical problems is student independence or self-regulated learning. Eladl & Polpol research (2020) states that students' self-regulated learning has an influence on students' creative problem solving abilities. This is also supported by (Runisah & Ismunandar research (2020) which states that there is a high correlation between self-regulated learning and creative thinking skills.

Based on these problems, a teacher should have the ability to organize and choose the right learning strategy to be used. Selection of an effective learning model to improve students' creative thinking skills in mathematical problem solving. The problem-solving learning model that can train students' creative thinking skills is the Creative Problem Solving learning model (Sawitri et al., 2020). The Creative Problem Solving learning model is a learning model that can develop students' creativity through problem solving. In the Creative Problem Solving learning model, students' ideas are prioritized and the right decision is made when solving problems (Nurdin et al., 2020).The Creative Problem Solving learning model uses creativity in problem solving and creates an active learning atmosphere, which places students at the center of learning and improves their creative thinking skills (Wibowo & Purnomo, 2023).

Therefore, this study aims to examine the effectiveness of the contextual approach CPS model in improving creative thinking skills in mathematics problem solving and describe creative thinking skills in mathematics problem solving in terms of Self Regulated Learning (SRL).

2. METHOD

This study uses a mixed research method that combines quantitative and qualitative research methods sequentially. This approach involves a two-phase data collection project where the researcher collects quantitative data in the first phase, analyzes the results, and then uses those results (or builds on them) in the second, qualitative phase. The quantitative results usually inform the types of participants to be selected for the qualitative phase and the types of questions to be asked of participants (Creswell & Creswell, 2018).The population of this study was all students of class XI SMA N 5 Semarang. The research sample was taken using cluster random sampling technique. The sample of this study were students of class XI-2 with a total of 72 students.While qualitative data was taken based on the level of Self Regulated Learning (SRL). While qualitative data is taken based on the level of Self Regulated Learning (SRL) of students. Grouping of students' self-regulated learning according to Table 2.1 (Arikunto, 2018).

Table 2.1 Self-regulated learning categorization group boundaries

Category	Criteria
$X \geq (\bar{X} + SD)$	High
$(\bar{X} - SD) \leq X < (\bar{X} + SD)$	Medium
$X < (\bar{X} - SD)$	Low

Data analysis in this research includes quantitative data analysis and qualitative data analysis. Quantitative data analysis includes initial stage data analysis and final stage data analysis. The data used in the initial stage data analysis is the pretest score of experimental and control class students which is used to determine the initial ability of students. Furthermore, for hypothesis testing includes tests, including the following:

1) Normality test
2) Homogeneity test
3) Classical Completeness Test (one-party proportion test)
4) Test the average difference using the t test.
5) Proportional Difference Test

Classical completeness testing is used to determine whether the percentage of students in contextual approach CPS learning who achieve individual completeness reaches 65%. The statistical hypothesis is as follows.

$H_0: \pi \leq 0,65$ (the proportion of students who are complete in CPS with a contextual approach does not reach 65% completeness),

$H_a: \pi > 0{,}65$ (the proportion of learners who completed the CPS with contextual approach reached more than 65%).

The conclusion is obtained by comparing the significance value with the α value. The α value used in this study is 0.05. If the sig value ≥ 0.05, then H_0 is accepted which means that the proportion of students achieving classical completeness $\leq 65\%$ and if the sig value > 0.05 then H_0 is rejected.

Proportional difference testing is used to determine whether the proportion of the completeness of creative thinking skills in mathematical problem solving of students who learn using the Creative Problem Solving learning model with a contextual approach is more than the proportion of students who learn using the discovery learning model. For the right party test, the hypothesis pair is.

$H_0: \pi_1 \leq \pi_2$ (The proportion of students who learn using the CPS learning model with a contextual approach is less than or equal to the proportion of students who learn using the discovery learning model).

$H_a: \pi_1 > \pi_2$ (The proportion of students who learn using the CPS learning model with a contextual approach is more than the proportion of students learning using discovery learning).

The calculation statistics used to test different proportions with the z test are as follows.

$$z = \frac{\left(\frac{x_1}{n_1}\right) - \left(\frac{x_2}{n_2}\right)}{\sqrt{pq\left\{\left(\frac{1}{n_1}\right) - \left(\frac{1}{n_2}\right)\right\}}}$$

with

$$p = \frac{x_1 + x_2}{n_1 + n_2} \text{ and } q = 1 - p$$

description:

x_1 : the number of students who completed the experimental class

x_2 : the number of students who completed the control class

n_1 : the total number of students in the experimental class
n_2 : the total number of students in the control class
p : overall proportion of events in both groups
q : the proportion of non-occurrence of the overall event in both groups.

The hypothesis testing criteria used are rejecting H_0 if $Z_{count} \geq Z_{table}$ and H_0 is accepted if $Z_{count} > Z_{table}$ with $Z_{table} = Z_{(0.5-\alpha)}$, and $\alpha = 5\%$ (Lidiana & Sukestiyarno, 2023). This test is used to answer the problem formulation of the effectiveness of CPS learning on students' creative thinking skills in mathematical problem solving.

Qualitative data analysis was used to describe students' mathematical creative thinking skills in terms of SRL in CPS learning. The analysis was carried out based on data from the posttest results of creative thinking skills in mathematical problem solving and interview data from each research subject. The documentation used is the results of students' work on the creative thinking ability test in solving math problems and the results of observations of students during class.

3. RESULTS AND DISCUSSION

At the initial stage, the pretest value data was analyzed to determine the initial state of the two samples.

3.1 Result

3.1.1 Normality Test

Table 3.1 Tests of Normality

	Class	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Pre_Test	Experiment	.092	36	.200*
	Control	.130	36	.130

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on table 2.1, the sig value of the two classes is 0.200 and 0.200 so that the sig value of the two classes is more than 5%, then $H0$ is accepted, meaning that the initial data comes from a normally distributed population. So, the sample comes from a normally distributed population.

3.1.2 Homogeneity Test

Table 3.2 Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Pre_Test	Based on Mean	.127	1	70	.723
	Based on Median	.101	1	70	.751
	Based on Median and with adjusted df	.101	1	69.998	.751
	Based on trimmed mean	.099	1	70	.753

Based on the table above, sig values of $0.723, 0.751, 0.751$ and $0.753 > 0.05$ are obtained. Since the sig value is more than 5% then H0 is accepted, this indicates that the variance of the experimental class is equal to the variance of the control class.

3.1.3 Initial data Mean Similarity Test

The average similarity test is used to determine whether the experimental and control class students, namely class XI-2 and XI-7, have the same initial ability or not. In this study, the average similarity test was calculated using the help of SPSS 25 through the Independent Sample T-Test test. The criteria in this hypothesis test are to accept H_0 if the sig value (2-tailed) > 0.05 and vice versa.

Table 3.3 Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	T	Df	Sig. (2-tailed)
Pre_Test	Equal variances assumed	.127	.723	-.421	70	.675

Based on the Independent Sample T-Test test, the sig (2-tailed) value is > 0.675, so H_0 is accepted. So it can be concluded that the two classes have the same average.

Based on the initial data analysis, it can be concluded that the sample comes from a population that is normally distributed, homogeneous, and has the same average initial score. Therefore, it can be concluded that the samples have the same initial condition.

After the initial data analysis, students in the experimental class were given treatment, namely the application of the CPS learning model in learning while students in the control class used the discovery learning model. After learning in both classes, the sample was then given a posttest of creative thinking skills in mathematical problem solving. The posttest results were then analyzed at the final stage to answer the problem formulation regarding the effectiveness of learning on creative thinking skills in mathematical problem solving. The final stage data analysis includes prerequisite tests (normality test and homogeneous test) and hypothesis testing as follows.

3.2 Effectiveness of CPS Learning on Creative Thinking Ability in Mathematics Problem Solving

The CPS learning model is said to be effective on the ability to think creatively in mathematical problem solving if it meets several criteria: (1) Hypothesis I: the mathematical creative thinking ability of students applied to CPS learning achieves classical completeness of more than 65%; (2) Hypothesis II: the average mathematical creative thinking ability of students applied to CPS learning is better than the average mathematical creative thinking ability of students applied to discovery learning; (3) Hypothesis III: the proportion of students who have completed learning who are applied to CPS learning is greater than the proportion of students who have completed learning who are applied to discovery learning. Before testing the hypothesis, it is necessary to conduct a prerequisite test, namely the normality test using the Kolmogorov Smirnov Test and the homogeneous test using the Levene Test with the help of SPSS 25 as follows.

3.2.1 Normality Test

Table 3.4 Tests of Normality

	Class	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Post_Test	Class Experiment	.129	36	.135
	Control Class	.108	36	.200*

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on table 3.4, the sig value of the two classes is 0.135 and 0.200 so that the sig value of the two classes is more than 5%, then $H0$ is accepted, meaning that the final data comes from a normally distributed population. So, the sample comes from a normally distributed population.

3.2.2 Homogeneity Test

Table 3.5 Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Post_Test	Based on Mean	3.359	1	70	.071
	Based on Median	2.920	1	70	.092
	Based on Median and with adjusted df	2.920	1	68.904	.092
	Based on trimmed mean	3.325	1	70	.072

Based on the table above, sig values of $0.071, 0.092, 0.092$ and $0.072 > 0.05$ are obtained. Since the sig value is more than 5% then H0 is accepted, this indicates that the variance of the experimental class is equal to the variance of the control class.

3.2.3 Hypothesis I

The first hypothesis in this research is the classical completeness test which is calculated using the one-sample proportion test (right side). Classical completeness in this study if more than 65% of students taught using CPS learning get a score with a minimum limit of 65. The following are the results of the proportion completeness test of the final data of creative thinking ability in mathematics problem solving in CPS with a contextual approach in the experimental class.

Table 3.6 Binomial Test

		Category	N	Observed Prop.	Test Prop	Sig. (2-tailed)
Experiment Class	Group 1	<= 65	5	.14	.50	.000
	Group 2	> 65	31	.86		
	Total		36	1.00		

Based on the Binomial Test table, it shows that the sig value is $0.000 < 0.05$. Because the sig.$0{,}000 < 0.05$ value, H_0 is rejected. So, it can be concluded that the proportion of students who are complete in CPS with a contextual approach reaches more than 65% completeness in the experimental class.

Table 3.7 Binomial Test

		Category	N	Observed Prop.	Test Prop.	Sig. (2-tailed)
Control Class	Group 1	<= 65	17	.47	.50	.868
	Group 2	> 65	19	.53		
	Total		36	1.00		

Based on the Binomial Test table, it can be seen that the sig. value is $0.868 > 0.05$. Because the sig value. $0.868 > 0.05$, then H_0 is accepted. So, it can be concluded that the proportion of students who are complete in CPS learning with a contextual approach does not reach more than 65% completeness in the control class.

3.2.4 Hypothesis Test II

The test of the average difference in the ability to think creatively in solving mathematical problems is carried out to determine whether there is a difference in the ability to think creatively in solving mathematical problems of students who learn using the CPS learning model with a contextual approach with students who learn using the discovery learning model. The test in this research uses the Independent Sample T-Test test using the help of SPSS 25.

The criterion for accepting H_0 is if the sig value ≥ 0.05. If the sig value ≥ 0.05 then H_0 is accepted which means that the two classes have the same average. If the sig value is < 0.05 then H_0 is rejected which means that the two classes have different averages. If H_0 is rejected, it is necessary to conduct further tests by looking at empirical values to see which class is better. The following is a different test of the average of the final data on the ability to think creatively in solving mathematical problems of students who learn using the Creative Problem Solving learning model with a contextual approach.

Table 3.8 Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	T	Df	Sig. (2-tailed)
Post_Test	Equal variances assumed	3.359	.071	4.424	70	.000

Based on the Independent Samples Test table, it shows that the sig value is $0.000 < 0.05$. Because the sig. $0.000 < 0.05$ value, H_0 is rejected. So, it can be concluded that the two classes have different averages. Because H_0 is rejected, it is necessary to do further tests by looking at the empirical average to find out which class is better. Here are the empirical averages of the experimental and control classes.

Table 3.9 Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Post_Test	Eksperiment	36	75.3222	8.59764	1.43294
	Control	36	65.1389	10.80990	1.80165

Based on the table above, the empirical mean of creative thinking ability in solving mathematics problems of students in the experimental class is 75, 32 while the empirical mean of creative thinking ability in solving mathematics problems of students in the control class is 65, 13. This shows that the average student who learns using the CPS learning model with a contextual approach is better than the average student who learns using the discovery learning model.

3.2.5 Hypothesis Test III

The difference in proportions test (right side) was conducted to test whether the proportion of students who achieved learning completeness with the CPS learning model was more than the proportion of students who achieved learning completeness with the Discovery Learning Model. Based on the calculation, the value of Z_{count} (1.82) $\geq$ Z_{table} (1.64) so that H_0 is rejected. Therefore, the proportion of students who achieve learning completeness with the CPS learning model is more than the proportion of students who achieve learning completeness using the discovery learning model.

3.3 Description of Learners' Creative Thinking Ability Based on SRL in CPS Learning

Classification of SRL The classification of SRL was carried out on 36 students in the experimental class (XI-2) using the SRL scale which had been validated by experts and tested for validity and reliability. The SRL scale consists of 38 statements. The following data presents the results of self-regulated learning classification in Table 3.3

Table 3.3 Self-Regulated Learning Class XI-2 Classification Results

Self-Regulated Learning	**Many Learners**	**Percentage**
High	5	15,75%
Medium	26	68,5%
Low	5	15,75%
Total	36	100%

Based on Table 3.2, it is obtained that students with moderate self-regulated learning dominate with a percentage of 68.5%. The percentage shows that the average level of self-regulated learning of experimental class students is moderate.

Six students were selected as subjects consisting of 2 students with high SRL level, 2 students with medium SRL level, and 2 students with low SRL level. Furthermore, the six subjects who have been given the creative thinking ability test in problem solving will be interviewed. After determining the research subjects based on the SRL classification, interviews were then conducted with the six research subjects and analyzed the results of the mathematical creative learning ability test by paying attention to the indicators of creative learning ability in problem solving consisting of: (1) fluency is the ability to solve open problems so as to produce correct and fluent answers or solutions, so that problem solving will be efficient; (2) flexibility is the ability to produce answers with many ideas with an unlimited number of answers to find answers to a problem; and (3) novelty is the ability to get different results or solution methods or new answers, meaning answers that are different from what is explained in class or different from classmates in answering a problem**.**

The following is the description of creative thinking ability in mathematics problem solving in terms of SRL.

Based on the analysis of the results of the self-regulated learning level questionnaire, six research subjects were selected which can be seen in Table 3.4.

Table 3.4 List of Research Subjects

No	**Subjects**	**Code**	**Category**

1	S-1	E-18	High self-regulated learning
2	S-2	E-05	High self-regulated learning
3	S-3	E-34	Medium self-regulated learning
4	S-4	E-17	Medium self-regulated learning
5	S-5	E-20	Low self-regulated learning
6	S-6	E-23	Low self-regulated learning

3.3.1 Subjects with High SRL

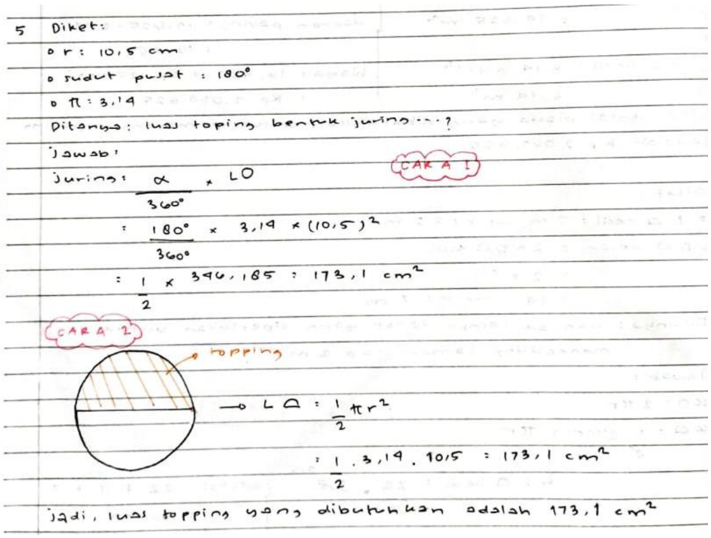
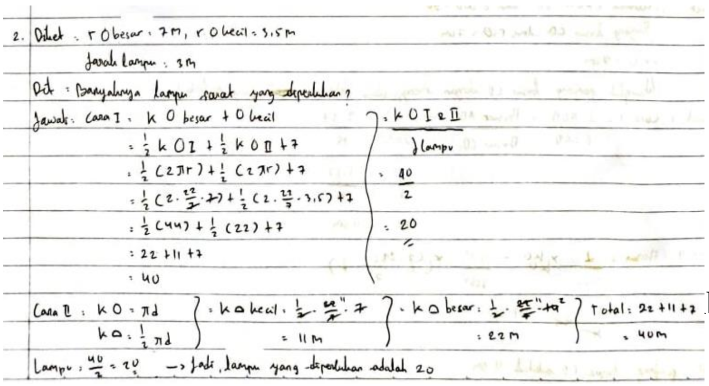


Figure 1. Problem Solving of High SRL Subjects

Based on the results of the analysis, it is found that students with high self-regulated learning tend to be in the ability to think creatively in mathematical problem solving very creatively.

3.3.2 Subjects with Moderate SRL



bjects

Figure 2. Problem Solving of Moderate SRL Subjects

Based on the results of the analysis, it is found that students with moderate self-regulated learning tend to be at the level of creative thinking ability in creative mathematical problem solving.

3.3.3 Subjects with Low SRL

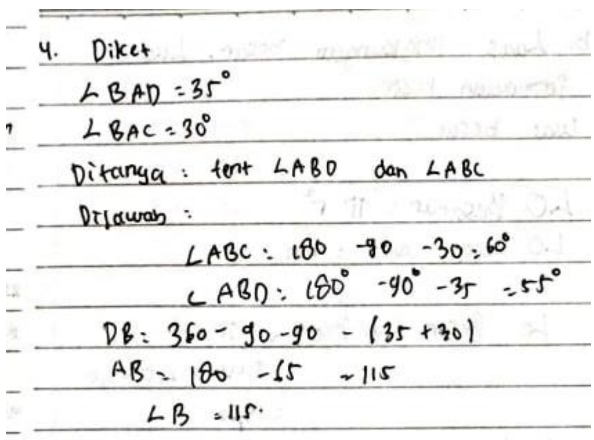


Figure 3. Problem Solving of Low SRL Subjects

Based on the results of the analysis, it is found that students with low self-regulated learning tend to be at the level of creative thinking ability in mathematical problem solving quite creative.

3.4 Discussion

Based on the results of quantitative data analysis, it was obtained that the proportion of experimental class students had achieved classical completeness of more than 65%, the average creative thinking ability in solving mathematical problems in the CPS learning model with a contextual approach was better than the average of students who learned using the discovery learning model and the proportion of creative thinking ability in solving mathematical problems in the CPS learning model with a contextual approach was better than the average of students who learned using the discovery learning model. Based on this, it can be concluded that the CPS learning model with a contextual approach is effective in developing creative thinking skills in mathematical problem solving.

Based on qualitative research results, Students with a high level of self-regulated learning tend to be able to fulfill the 3 indicators of creative thinking ability, namely fluency, flexibility, and novelty. This is supported by Eladl & Polpol research (2020) which states that students' self-regulated learning has an influence on students' creative problem solving ability.

Learners with a moderate level of self-regulated learning are only able to fulfill two indicators of creative thinking ability, namely fluency and flexibility. This is supported by research by Munahefi et al. (2022) that students with moderate self-regulated learning fulfill most of the existing indicators of mathematical creative thinking ability. In line with the research of Firdaus et al. (2016) showed that students with moderate mathematical creative thinking ability were only able to solve problems with two indicators of creative thinking ability, namely fluency and flexibility.

Learners with low self-regulated learning tend to be at the level of creative thinking ability in mathematics problem solving quite creative. Learners are only able to fulfill one indicator of creative thinking ability, namely fluency. In line with the research of Partayasa et al. (2020) shows that students who have lower mathematical creative thinking skills tend to find it more difficult to understand the mathematical problems given. This greatly impacts the mistakes made both in modeling the problem and determining the solution strategy.

Based on the results of research on the ability to think creatively in solving mathematical problems of the three levels of self regulated learning, it is known that for the high level of self regulated learning is at the ability to think creatively in solving mathematical problems which means very creative, the moderate level of self regulated learning is at the ability to think creatively in solving mathematical problems which means creative, while for the low level of self regulated learning is at the ability to think creatively in solving mathematical problems which means less creative. This is because based on the magnitude of the increase in creative thinking ability in mathematical problem solving, each self regulated learning level, namely high and medium self regulated learning levels are both at a moderate increase, while students with low self regulated learning levels are at a low increase. This means that students with low levels of self-regulated learning after being treated with the CPS learning model only experience an increase in creative thinking skills in solving low mathematical problems.

4. CONCLUSION

This study shows that the application of Creative Problem Solving (CPS) learning model with contextual approach can improve students' creative thinking ability in mathematics problem solving. The results showed that (1) CPS learning with contextual approach was effective in improving creative thinking ability in mathematics problem solving, and (2) research subjects with high SRL category were able to fulfill all indicators of creative thinking ability in mathematics problem solving, namely fluency, flexibility and novelty; research subjects with medium SRL category only fulfilled two indicators of creative thinking ability in mathematics problem solving, namely fluency, and flexibility; research subjects with low SRL category were only able to fulfill the indicator of creative thinking ability in mathematics problem solving, namely fluency.

This study has limitations in terms of the number of research subjects limited to one school. Therefore, it is recommended to conduct similar research with a wider range of subjects in order to provide a more comprehensive picture of creative thinking skills in mathematics problem solving in terms of self-regulated learning. In addition, future research can also explore other factors that influence creative thinking skills in mathematics problem solving.

5. ACKNOWLEDGEMENTS

The authors would like to thank and express their highest appreciation to all researchers whose articles were referenced in the writing of this article.

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