IJEDs
http://ijeds.ppj.unp.ac.id/index.php/IJEDS
International Journal of Educational Dynamics
Vol. 3 No. 1 (pp. 89-101) December 2020
p_ISSN 2655-4852
e_ISSN 2655-5093

IMPROVEMENT OF STUDENTS' MATHEMATICAL CRITICAL AND CREATIVE THINKINGABILITIES THROUGH PROBLEM-BASED LEARNING APPROACHES WITH SIDIA SOFTWARE

***Nur Hasanah, Solfema, Hendra Syarifuddin, Farida**

Master of Basic Education – Universitas Negeri Padang
Email: nurhasanah9448@yahoo.com

Received: 01 Dec. 2020, Revised: 03 Jan. 2021, Accepted: 05 Jan. 2021

ABSTRACT

The ability to mathematically thinkingcritically and creatively is a very important skill for every student in learning mathematics. To improve this ability, it is necessary to have a learning approach that allows students to make observation and exploration in order to build their own knowledge. In general, three-dimensional geometry is difficult to explain by teachers in class and difficult for students to understand. Problem-based learning with SIDIA software is one of the lessons that can be applied in the class. The main objective of this research on three-dimensional geometry is to examine the increase in critical thinking and mathematical creative abilities between students who receive SIDIA software-assisted problem-based learning and students who receive conventional learning, the relationship between mathematical critical and creative thinking abilities, and students' attitudes towards this learning. The subjects of this research are the students of SMA Negeri in Padang City with a sample of class X students. Based on the results of the data analysis, it showed that students who received problem-based learning assisted by SIDIA software are better than students who received conventional learning. There is a significant relationship between the ability to mathematically thinkingcritically and creative, and in general students who get problem-based learning assisted by SIDIA software show a positive attitude.

Keywords: critical, creative, problem-based, SIDIA.

INTRODUCTION

Developing students' thinking skills is the focus of mathematics educators in the class. According to Sabandar (2008), learning mathematics is closely related to activity and process of learning, and also thinking because the characteristics of mathematics are a science and human activity, which is mathematics is a pattern of thinking, a pattern of organizing logical proof, using defined, clear, and accurate terms. The pattern of thinking in mathematical activities is divided into two, which are low-order mathematical thinking and high-order mathematical thinking. Anderson (2004) stated that when critical thinking is developed, a person will tend to seek the truth, think openly and tolerant of new ideas, can analyze problems well, think systematically, full of curiosity, mature in thinking, and can think critically independently. Meanwhile, according to *Learning and Teaching Scotland* (LTS, 2004) if the ability to think creatively develops in a person, it will generate many ideas, make many connections, have many perspectives on something, create and do the imagination, and care about result.

According to Appelbaum (2004), the development of critical thinking in mathematics in the class can be done by carrying out activities such as comparing, contradicting, inducing, generalizing, sorting, organizing, proving, linking, analyzing, evaluating, and making patterns, sequencing them on an ongoing basis. Meanwhile, according to Glazer (2004) critical thinking uses three indicators, which are: 1) Proof is the ability to prove a statement deductively (using previously studied theories); 2) Generalization is the ability to generate patterns of problems faced for a broader category; and 3) Problem solving is the ability to identify elements that are known, which are asked, and check the adequacy of the elements needed in the problem, compile mathematical models and solve them, and also check the correctness of the results or answers.

Related to creativity, Silver (1997) stated that there are two views on creativity. The first view is called the view of genius creativity. According to this view, creative action is seen as a rare mental trait produced by extraordinarily gifted individuals through the use of extraordinary, rapid, and spontaneous thought processes. This view says that creativity cannot be influenced by learning and creative work is more of a sudden occurrence rather than a long process to completion like what is done in school. Torrance (1969) defines in general, creativity as a process of understanding a problem, looking for possible solutions, drawing hypotheses, testing and evaluating, and communicating the results to others. In the process, the results of creativity include new ideas, different perspectives, solving problem chains, recombining ideas or seeing new relationships between these ideas. Torrance describes four components of creativity, which are: 1) Fluency, which is having many ideas in various categories; 2) Flexibility, which is having various ideas; 3) Originality, which is having new ideas to solve problems; and 4) Elaboration, which is being able to develop ideas for solving problems in detail.

In the application of the mathematics learning process in the class, generally mathematics teachers still tend to concentrate on problem solving exercises that are procedural and accommodate the development of low-order thinking skills and lack in developing high-order thinking skills. As stated by Silver (Turmudi, 2009) that in conventional learning, daily student activities generally watch their teacher solving the questions on the blackboard then ask students to work alone in the provided textbooks or student worksheets. According to Sumarmo (2000), to be able to develop mathematical thinking skills in learning, teachers also need to encourage students to be actively involved in discussions, ask and answer questions, think critically, explain every answer given, and ask reasons for each answer submitted.

The problem-based learning model is a learning model that involves dominant student activity, while the teacher's role is more as a facilitator. Seng (2000); Putra (2010) stated that problem-based learning applied to students can improve critical thinking skills. Meanwhile, Thomas (Roh, 2003) stated that because problem-based learning begins with a problem that must be solved, students are directed to have critical and creative thinking skills. This learning helps students to process information that already exists in their minds and organize their own knowledge about the social world and its surroundings. Apart from its strengths, Lee (2004) revealed some of the weaknesses of PBM, such as: 1) More time is needed in learning; 2) Constraints on teacher factors that are difficult to change orientation from teaching teachers to learning students; and 3) The difficulty of designing problems that meet the standards of problem-based learning.

The teacher's role in involving student activeness can help to understand material that is still considered difficult by most students. One of the mathematics subject matter that is considered difficult and very weakly absorbed by students in school is three-dimensional geometry. Research conducted by several experts shows that students at the high school also have very little knowledge or experience regarding the properties of geometric spatial shapes (Jiang, 2008). The difficulty of this three-dimensional geometry material is not only experienced by students but also by teachers in teaching it. Without teaching aids, it is quite difficult to stimulate students' visualization power, while from the students themselves to understand and visualize what the teacher explains is not easy.

All students who study geometry go through the Van Hiele stages namely Visualization, Analysis, Abstraction, Formal and Rigor Deduction in the same order, and it is not possible to skip levels. However, when a student starts to enter a new level is not always the same between one student and another. In addition, the process of development from one stage to the next is not primarily determined by age or biological maturity, but is more dependent on the teaching of the teacher and the learning process that students go through (Crowley, 1987). According to Sabandar (2002), ideally in teaching geometry in schools, adequate media should be provided so that students can observe, explore, try and find geometric principles through informal activities and then continue with formal activities and apply what they learn. Meanwhile, according to Kusumah (2007); Nova et al (2020), because of the concepts and high-level skills that have a relationship between one element and one other element are difficult to teach through books alone. Therefore, mathematics learning will be faster if learning activities in the classroom are introduced to computers that are used effectively.

SIDIA software is computer software that can display variations in three-dimensional geometric shapes, providing facilities for exploration, investigation, interpretation and solving mathematical problems quite interactively (Oldknow and Tetlow, 2008). One of the advantages of this software is that it can prove what cannot be proven on the board.

The results of the research by Accascina and Rogora (2006) show that SIDIA software is very effective in introducing three-dimensional geometric shapes to students and provides sufficient visual power. Mithalal (2009) who conducted research on 10th grade students in France, stated that with SIDIA, students can see three-dimensional shapes from various positions and it can be easier to bring out students 'visual power and make it possible to construct spatial shapes so that they can affect students' mathematical reasoning. While Petrovici *et al* (2010) stated that the use of SIDIA software in secondary schools can improve understanding and creativity skills,improve students' abilities in discussing with peers and teachers, can develop imaginative abilities and visualization of space, can link theory and application, be efficient in learning time, increase self-confidence in contributing to groups.

METHODS

The variables in this study are problem-based learning assisted by SIDIA software as independent variables and the ability to think critically and creatively in mathematics as the dependent variable. The population in this study were all students of class X SMA Negeri in Padang City. The sample chosen is one of the class X which is included in the medium level. The consideration of taking class X because the SIDIA program is related to three-dimensional geometry which is given in class X in second semester. The sample in this study consisted of 2 classes, which are the experimental class with the problem-based learning approach assisted by the SIDIA software and as a control class with conventional learning.

The samples were determined using the technique of "purposive sampling" (Sugiyono, 2008).

The instruments used in this study are tests and non-tests. The test instrument is a question of mathematical critical thinking abilities and creative thinking abilities in the form of descriptions, while the non-test instrument is a scale of attitudes about student opinions on the problem-based learning approach assisted by the SIDIA software during the learning process. Students'mathematical critical thinking abilitieswhich are measured from the given questions including proof, generalization, and problem solving, and for students' mathematical creative thinking abilities include fluency, flexibility, authenticity, and elaboration. The instrument that will be used in this study has been tested beforehand on high school students who have obtained three-dimensional geometry lessons.

The calculation of the instrument validity of the items is done using the Pearson Product Moment correlation formula with the standard interpretation that stated by Arikunto (2009). The calculation of instrument reliability for questions in the description form uses the Alpha formula. The distinguishing test uses the upper and lower grade 27% rule. The difficulty level of the questions is categorized as difficult, medium, and easy. Meanwhile, interpretation of the normalized gain index is carried out based on the gain index criteria in Hake (1999).

$$g = \frac{postT - preT}{maxT - preT}$$

g = gain
postT = post-test score
preT = pre-test score
maxT = ideal score

Data analysis using SPSS 17.0 to determine the statistical test used, first the normality of the data and the homogeneity of the variance were tested. Hypotheses 1 and 2 were tested using the Independent Samples t-Test for the experimental class and the control class. The third hypothesis was tested using the correlation test. The statistical hypothesis:

$H_0 : \mu_e = \mu_k$

$H_1 : \mu_e > \mu_k$

The attitude scale used is a Likert scale which consists of 25 statement items with four answer choices, which are strongly agree (SS), agree (S), disagree (TS), strongly disagree (STS). This attitude scale is given to students in the experimental class which is used to determine students' attitudes towards mathematics learning with problem-based learning assisted by SIDIA software. To analyze student responses to the questionnaire, two types of response scores were used, such as, student response scores given through questionnaires and neutral response scores. If the subject's score is greater than the number of neutral scores, then the subject has a positive attitude, and vice versa. The response scoring for each statement is stated non-uniformly, which is based on the distribution of student responses to an item of statement (Anwar, 2003; Chandra et al, 2019).

RESULT AND DISCUSSION

The objective to this study is to determine the increase in mathematical creative and critical thinking skills of students who get to learn with a problem-based approach assisted by SIDIA software and students who get conventional learning, to determine the relationship between students'mathematical creative and critical thinking skills in the experimental class and the control class after lesson is carried out, and to find out students' attitudes towards learning using a problem-based approach assisted by SIDIA. Data processing in this study was carried out using SPSS 17.0 software and Microsoft Office Excel.The data obtained and analyzed in this study are the results score of the pre-test, post-test, gain scores of students'mathematical creative and critical thinking abilities, as well as questionnaire data on the students' attitudes scale.

3.1 Result of Research

3.3.1 Students' Initial Ability to Critical and Creative Mathematical Thinking

Pre-test was done to find out the students' initial ability to critical and creative mathematical thinking.

Table 1. Description of Initial Ability to Critical and Creative Mathematical Thinking

Aspect	Ideal	Pre-test of Experimental Class					Pre-test of Control Class				
	Score	Min	Max	$\bar{X}$	*S*	%	Min	Max	$\bar{X}$	*S*	%
Critical Thinking	12	0	6	2,47	1,55	20,56	0	5	2,47	1,50	20,56
Creative Thinking	16	2	8	4,8	1,65	30	1	7	4,17	1,66	26,04

Table 1 shows that the distribution of data in the experimental class and control class is relatively the same, the average pre-test results of students'mathematical critical thinking abilities in the experimental and control classes are not different, the students' creative thinking abilities in the experimental and control classes have a difference of 0.63 or 3, 96%.

This difference needs to be tested further to find out the pretest scores in the two classes are significantly different. Before doing the average difference test, it is necessary to test for normality and test the homogeneity of the students' pre-test scores.

Table 2. Normality Test Result of the Experimental Class and Control Class Pre-test

Aspect	Experimental Class Kolmogorov-Smirnov[a]				Control Class Kolmogorov-Smirnov[a]			
	Statistic	df	Sig.	Conclusion	Statistic	df	Sig.	Conclusion
Critical	0,135	30	0,173	Normal	0,146	30	0,101	Normal
Creative	0,133	30	0,183	Normal	0,132	30	0,196	Normal

Table 3. Homogeneity Result of Pre-test Variances in Experimental and Control Class

Aspect	Levene Statistic	Sig.	Conclusion
Critical	0,000	1,000	Homogenous
Creative	0,016	0,900	Homogenous

The results of the normality test and homogeneity test using SPSS 17.0 at a significance level of $\alpha = 0.05$ showed that the pre-test score data on the ability to think critically and creatively in mathematics in the experimental class and control class are normally distributed and have homogeneous variances.

hile the results of the average difference test between the experimental and control class pre-test for the ability to think critically and creative mathematically show to accept H0, meaning that there is no difference in students' mathematical critical thinking abilities in the experimental and control classes. The students' initial abilities in the experimental class and the control class are the same.

Table 4. Test Results of Mean Difference of Pre-test Scores for Experimental Class and Control Class

Aspect	Variance	t	Sig.	Annotation
Critical	Homogenous	.000	1.000	Accept H_0
Creative	Homogenous	1.482	.144	Accept H_0

3.3.2 Student's Final Abilities of Critical and Creative Mathematical Thinking

To determine the increase in mathematical creative thinking abilities, it is done by analyzing the post-test score. The results of the calculation show that the average post-test score of the experimental class is more spread out than the control class, the average post-test score of the mathematical creative and critical thinking abilities in the experimental class is better than the control class. The difference in the average score of critical mathematical thinking abilities between the experimental class and the control class is 2.03 or 17.78%, while the difference in creative thinking abilitiesis 3.20 or 20%.

Table 5. The Description of Post-test Score Result

Aspect	Ideal Score	Post-test of Experiment Class					Post-test of Control Class				
		Min	Max		%	*S*	Min	Max		%	*S*
Critical	12	3	12	8,10	67,50	2,14	3	10	5,97	49,72	1,81
Creative	16	4	15	11,33	70,83	2,64	4	12	8,13	50,83	2,16

The results of the average difference test results in the experimental and control class post-test for the ability to think critically and creative mathematically show to reject H0, this means that there are differences in students' mathematical creative and critical thinking abilities in the experimental and control classes.

Table 6. Test Result of the Difference Average Post-test Score for Experimental and Control Class

Aspect	Variance	T	Sig.	Annotation
Critical	Homogenous	4.170	0.000	Tolak H_0
Creative	Homogenous	5.133	0.000	Tolak H_0

3.3.3 The Increasing Students' Critical and Creative Mathematical Thinking

The results of the normality and homogeneity test showed normalized gain data on the ability to think critical mathematically in class with normal distribution and homogeneity.

Table 7. Result of Normalized Gain Normality Test of Mathematical Critical Thinking Ability

Aspect	Group	Kolmogorov-Smirnov	Sig.	Conclusion	Annotation
Critical Thinking	Experimental	0,133	0,173	Accept H_0	Normal
	Control	0,146	0,101	Accept H_0	Normal

Table 8. Result of Variance Gain Homogeneity Test for Experimental and Control Class

Aspect	Levene Statistic	Sig.	Conclusion	Annotation
Critical Thinking	0,000	1,000	Accept H_0	Homogenous

The normalized gain difference test of students' mathematical creative and critical thinking abilities in the two classes aims to prove the first and second research hypotheses.

Table 9. Result of Difference Test Result of Average Gain Score

Gain	t	Sig.	Annotation
Critical	6,236	0,000	H_0 accepted
Creative	4,532	0,000	H_0 rejected

Table 9 shows that H0 is rejected, meaning that the increase in critical and creative thinking skills of students who receive problem-based learning assisted by SIDIA software is better than students who receive conventional learning. But the normalized gain average in the experimental class is better than the control class. The difference in the average gain of the experimental and control class mathematical critical thinking ability is 0.250 and the difference in creative thinking is 0.210.

From the mathematical critical thinking ability test questions given to the experimental class based on the specified indicators, it shows an increase in the average gain score achieved for the three indicators including the moderate category. Whereas for the control class, from the three indicators of the mathematical critical thinking skills test given, an increase from the average gain score in the medium and low categories. In the application of the problem-based learning approach assisted by SIDIA software in the experimental class, the development of students' mathematical creative thinking abilities on indicators of flexibility and authenticity is better than indicators of fluency and elaboration. The control class shows an increase in the ability to think creatively in the high category on authenticity indicators, moderate categories on fluency and low categories on indicators of flexibility and elaboration. In general, the improvement of students' mathematical critical and creative thinking skills through the problem-based learning approach assisted by SIDIA software is better than students who receive conventional learning.

Attitude Scale: The giving of attitude scales to students in this study was based on affective attitudes which aim to determine students' attitudes towards mathematics learning in general, student attitudes towards problem-based learning, student attitudes towards learning assisted by SIDIA software, and student attitudes towards critical and creative thinking mathematically. This attitude scale consists of 25 statements that are divided into 14 positive statements and 11 negative statements. Students' attitudes towards mathematics were analyzed by showing a preference for mathematics and the seriousness of learning mathematics. The attitude of the students was positive. This can be seen from the student attitude score which is greater than the neutral attitude score. The score for the student's attitude was 3.18 while the score for the neutral attitude was 2.69. It can be concluded that the students' attitudes are positive towards mathematics. Students stated that math was fun, not boring, and they really paid attention to the lesson.

Table 12. Students' Attitude Towards Mathematics

Students' Attitude	Indicators	Statement		Attitude Score			
				Neutral		Students	
		No	Trait	Item	Mean	Item	Mean
Towards Mathematics	Shows fondness toward mathematics	1	+	2,5	2,69	2,80	3,18
		3	-	2,5		2,97	
	Shows seriousness in learning athematics	6	-	2,5		3,03	
		8	+	3,25		3,93	
Towards Problem-based Learning	Indicates participation in class discussion	2	+	2,5	2,75	3,10	3,08
		4	-	3,25		3,80	
	Shows approval of learning activity in	5	+	2,75		2,87	

Students' Attitude	Indicators	Statement		Attitude Score			
				Neutral		Students	
		No	Trait	Item	Mean	Item	Mean
	class	7	+	2,75		2,90	
		18	-	2,5		2,73	
Students' Attitudes Towards Learning Geometry Assisted by SIDIA Software	Shows fondness towards the delivery of the learning subject using SIDIA Show approval of learning three-dimensional geometry with SIDIA	12	-	3	2,96	4,10	3,73
		15	+	3		4,27	
		13	+	2,5		2,80	
		16	-	3,5		4,00	
		20	+	3,25		4,30	
		23	-	2,5		2,93	
Towards the Question of Critical and Creative Mathematical Thinking	Shows fondness towards the given question Shows sincerity in solving the given questions	9	+	2,5	2,83	2,73	3,35
		10	-	3		4,10	
		14	+	2,5		2,83	
		19	-	3,75		4,20	
		11	+	2,5		2,77	
		17	+	3,25		2,93	
		21	-	3,25		4,03	
		22	+	3,25		4,07	
		24	-	2,5		2,87	
		25	+	2,5		2,77	

Students' Attitude Towards Problem-based Learning: Students' attitudes towards problem-based learning are analyzed by submitting several statements regarding the approval of the use of Student Worksheets in learning and the approval of participation activities in class discussions. Students' attitudes towards problem-based learning are positive. This can be seen from the results of the student attitude score of 3.08 and this score is greater than the score for neutral attitudes, which is 2.75. It can be concluded that in general students expressed a positive attitude towards problem-based learning given. Students stated that they felt helped by the LKS, enjoyed working in groups, proud to be involved in class discussions, and found mathematics to be interesting.

Students' Attitude Towards Learning Assisted by SIDIA Software: Students' attitudes towards learning three-dimensional geometry with the help of SIDIA software, shown through indicators that their preference for using SIDIA to help solve problems and show agreement to learn three-dimensional geometry with. The score of the students' attitude was 3.08 greater than the neutral score of 2.75. It can be concluded that students' attitudes are positive towards learning mathematics assisted by SIDIA software. Students said they liked learning mathematics using computers, and it was easy to understand geometry with the help of SIDIA software.

Students' Attitude Towards the Questions of Critical and Creative Mathematical Thinking: The students' attitudes are analyzed by showing a preference for the questions given and showing seriousness in solving the questions given. From these two indicators, the student's attitude score was 3.35 which was greater than the neutral score 2.83. It can be concluded that students have a positive attitude towards mathematical creative and critical thinking problems. Most students feel challenged by the questions given, be creative, and believe there is always a way to solve these problems.

3.2 Discussion

Based on the post-test scores for the mathematical critical thinking skills of the experimental class students who are given learning using a problem-based approach assisted by SIDIA software, they are better than students in the control class who received conventional learning. Students in the experimental class obtained an average score of 8.10 and the control class is 5.97 from the maximum score of 12. The average gain score for the experimental class is 0.629 and the control class is 0.379. Thus, the increase in mathematical critical thinking skills in the experimental class is better than the control class.

Based on the normalized gain category, the increase in students' mathematical critical thinking skills in the experimental and control classes is in the moderate category, but when viewed from the average gain of the mathematical critical thinking ability of each indicator, the increase in the evidentiary indicator in the experimental class is better than the control class which categorized low. In addition, although they are both in the medium category, the normalized gain in the experimental class is better than the control class.

The table above shows the difference in normalized gain between the experimental and control classes on the generalization indicator which are both in the moderate category is 0.350 and the problem-solving indicator is 0.130. The results of this data collection show that students who learn using a problem-based approach assisted by SIDIA software get better results than students who receive conventional learning. This is possible because learning using a problem-based approach assisted by SIDIA software is a learning approach that emphasizes the activeness of students to be able to reconstruct their own knowledge, through the problems given which motivate students to improve their critical thinking skills in solving math problems.

The increase in the proving ability of the experimental class shows that the use of SIDIA software has an effect on increasing the visualization of students, so that students can avoid understanding the wrong concept of building space. As the opinion of Accacina and Rogora (2006), which states that students' mistakes in understanding the three-dimensional form can cause errors in solving the problems given. There is an increase in students' generalization skills that are better than the control class, showing that by using SIDIA software, students are easy to make regular pattern relationships from existing objects, so that it is easier to produce conjectures (guesses) than the control class. According to Kosa and Karakus (2010), SIDIA software will help students build their spatial visualization power to better understand the geometry material being taught.

Better problem-solving abilities are greatly supported by how easy students explore three-dimensional geometric shapes without worrying about making mistakes. Exploration like this will add knowledge and experience for students in solving problems. As Shannon (2008) argues, solving a problem in mathematicsactually creates a few more problems, so the ability to know exactly what to do is required.

The mathematical creative thinking skills based on the post-test scores and the gain of the experimental class given, learning using a problem-based approach assisted by SIDIA software are better than students in the control class who are subjected to conventional learning. Students in the experimental class obtained an average score of 11.33 and the control class is 8.13 from a maximum score of 16. On the average gain score as a whole the experimental class is 0.631 and the control class is 0.421, the increase in both classes was moderate. But if we look at each indicator, the quality of the experimental class creative thinking ability is in the high and medium categories. The high category indicator is flexibility, which is the ability to answer a problem in more than one way and authenticity which is the ability to answer in its own way. Whereas in the control class, the indicator is high on the ability to answer in its own way. The high category in this control class is because the type of problem given relates to the determination of the angle in the cube plane, which is greatly influenced by the knowledge of the previously studied trigonometric material. But in general, it shows that the quality of the experimental class mathematical creative thinking ability is better than the control class.

The improvement of students' thinking skills in fluency and flexibility is strongly influenced by the SIDIA software which can make it easier for students to make observations and exploration by rotating, shifting, enlarging, shrinking and making variations of three-dimensional objects with lengths and angular sizes which automatically change as desired. So that students can freely generate many opinions, methods, and solutions in various ways. According to Mithalal (2009), exploration using SIDIA can enable students to find easier steps in solving problems.

As for the improvement of students'thinking skills in elaboration and authenticity, it is possible because students are trained with questions that provoke students' creativity to add object parts that can facilitate problem solving. This process is carried out by students repeatedly with collective efforts in groups to answer the problems presented, so that the imagination of students is built which allows them to obtain solutions that have not existed before. Dahan (2008) states that the use of SIDIA software provides a means for users to develop various ideas and imagination in constructing geometric shapes.

The problems faced by students as well as discussion activities in class that can affect the growth of students 'self-confidence to make their own discoveries in solving problems, are quite influential in increasing students' mathematical creative and critical thinking skills. With the existence of discussion activities in this learning, it allows students to interact with classmates and with other classes in expressing opinions, asking questions, responding to other people's opinions, explaining their own thinking in solving problems, so that students' mathematical creative and critical thinking skills increase.

Discussion activities and student presentations in learning activities assisted by SIDIA software can increase interaction between students, which is indirectly and effective in building a thinking learning environment. As the opinion of Sabandar (2008), which states that it takes a teacher's effort to deliberately embody and create a thinking class that is to develop students' mathematical thinking skills. The results obtained indicate that students who learn using a problem-based approach assisted by SIDIA provide better post-test results of critical and creative thinking skills than students who learn conventionally. Oldknow and Tetlow (2008) stated that the use of SIDIA in addition to increasing students 'visualization power, can also improve students' problem-solving abilities and creativity. Based on the statistical test of hypothesis 3, there is a relationship between students' critical thinking and creative mathematical abilities, using the Pearson Product Moment correlation formula, thecorrelation coefficient of experimental classis 0.439 and the control class is 0.310. The interpretation of this r value shows that the correlation between students' mathematical critical thinking and creative abilities in the experimental class is quite significant. This means that the existence of this correlation value can sufficiently show that students who have the top rank on the mathematical critical thinking ability test are likely to also be ranked above on the mathematical creative thinking ability test and vice versa.

On the other hand, students generally give positive responses to problem-based learning assisted by SIDIA software on three-dimensional geometry material. About 19 students consistently stated that through the learning they carried out, mathematics lessons are felt to be fun and not boring. The number of students who consistently showed seriousness in learning was 23 people. According to students, the use of worksheets can help in understanding three-dimensional geometry material. This statement has been consistently responded to positively by 23 students. Also 18 students consistently agreed to group activities with discussions and presentations making mathematics lessons interesting.

The use of the SIDIA software is responded positively by 25 students who feel helped to understand the three-dimensional geometry. Students also feel that they understand the three-dimensional geometry material taught by SIDIA faster and will propose to class teachers to use mathematics software such as SIDIA in the learning process in class. This statement has consistently been responded to positively by 18 students. And with the questions given, 17 students consistently argued that these questions made students feel there are challenges so that ideas developed, creativity emerged in an effort to find solutions and are able to express their opinions in discussions. This finding is in accordance with the opinion of Wahyudin (2008), who said that if students can connect mathematical ideas, their understanding is deeper and more durable.

Learning by using this SIDIA-assisted problem-based approach can contribute more to the effort to improve students' mathematical creative and critical thinking skills compared to conventional learning. This can be seen from students' answers who stated that they prefer learning as given and learning like this helps them to get used to expressing their thoughts through the discussions they do, argue, ask questions, and find new knowledge that was never thought of before. Students think this learning makes students happy to work together in solving the questions given.

CONCLUSION

Based on the results of research and discussion, it can be concluded: 1) Increased mathematical critical thinking abilities of students who receive a problem-based learning assisted by SIDIA are better than students who receive conventional learning; 2) Improved mathematical creative thinking abilities of students who receive the problem-based learning assisted by SIDIA are better than students who receive conventional learning; 3) There is a significant positive relationship between students' critical thinking and creative mathematical skills in problem-based learning with the help of SIDIA software. This shows that the ranking obtained by students on mathematical critical thinking skills with the rank obtained in mathematical creative thinking skills is almost the same; and 4) Students' attitudes towards three-dimensional geometry learning with a problem-based learning assisted by SIDIA for critical and creative mathematical thinking questions are very positive. The student's attitude score is greater than the neutral score.In addition, students generally stated that through learning carried out with the help of SIDIA software, mathematics lessons were fun, they feel that there are challenges so that ideas developed, creativity emerged in an effort to find solutions and could express their opinions in discussions.

REFERENCES

Accacina, G and Rogora, E. (2006). *Using SIDIA Diagrams for TeachingGeometry*. [Online]. Available: http://www.didmatcofin05.unimore.it/on-line/Home/Prodotti/Prodotti2006/documento/15002331.html.

Anderson, T., Garrison, D.R., dan Archer, W.(2004). *Critical Thinking, CognitivePresence, Computer Conferencing in Distance Learning*. [Online]. Available:http://communityofinquiry.com/files/CogPres_Final.pdf

Appelbaum, P. (2004). *Critical Thinking and Learning*. [Online]. Available: http://gargoyle.arcadia.edu/appelbaum/encyc.htm.

Arikunto, S. (2009). *Dasar-dasar Evaluasi Pendidikan*. Jakarta: Bumi Aksara.

Azwar, S. (2003). *Penyusunan Skala Psikologi*. Yogyakarta: Pustaka Pelajar.

Chandra, D., Wilis, R., Frananda, H., Rahmi, L., Arif, D. A., Wijayanto, B., Putra, A. 2019. Pembuatan Peta Timbul Sebagai Media Pembelajaran Geografi [Making Embossed Maps as Learning Media for Geography]. PEDAGOGIA: Jurnal Pendidikan, 8(2), 211-221.

Crowley, L.M. (1987) "*The Van Hiele Model of the Development of GeometricThought," in Learning and Teaching Geometry, K-12.* National Council of Teachersof Mathematics.

Dahan, J. (2008). *Modelling with SIDIA to Enhance A More ConstructivistApproach to 3D Geometry*. [Online]. Available:http://atcm.mathandtech.org/EP2008/papers_full/2412008_15338.

Glazer, E. (2004). *Using Web Sources to Promote Critical Thinking in HighSchool Mathematics.* [Online]. Available: http://math.unipa.it/~grim/AGlazer79-84.Pdf.

Hake. R. (1999). *Analyzing Change/Gain Score*. [Online]. Available: http://www.physics.indiana.edu/~sdi/AnalysingChange-Gain.pdf.[December 15th, 2010]

Jiang, Z. (2008), *Explorations and Reasoning in the Dynamic GeometryEnvironmen*t. [Online]. Available:http://atcm.mathandtech.org/EP2008/papers_full/2412008.15336.pdf

Kusumah, Y.S.(2007).“*Peningkatan Kualitas Pembelajaran dengan CoursewareInteraktif*. Semarang.

LTS. (2004). *Learning Thinking*. Scotland: Learning and Teaching Scotland.

Mithalal, L. (2009). *3D Geometry and Learning of Mathematical Reasoning*. [Online]. Available: http://www.inrp.fr/publications/edition-electronique/cerme6/wg5-13-mithalal.pdf

Nova, S., Chandra, D., Edial, H., Rahmi, L., Putri, S. K., Putra, A., Mandriyanti, M. 2020. Training on the Making of 3D Geographic Learning Media (Models of Earth Fours and Fractions and Earth Structures) in SMA N 2 Batang Anai-Padang Pariaman Regency and SMA N 5 Pariaman City. International Journal of Progressive Sciences and Technologies, 23(2), 271-276.

Oldknow, A. and Tetlow, L. (2008). *Using Dynamic Geometry Software toEncourage 3D Visualisation and Modelling*. [Online]. Available:http://php.radford.edu/~ejmt/Stuff/eJMT-Template.doc

Petrovici, A. et all. (2010). *SIDIA-The Instrument to Make The Didactic ApproachMore Efficient*. [Online]. Available: http://anale-informatica.tibiscus.ro.download/lucrari/8-2-21-Petrovici.pdf.

Putra, A. (2010). Penerapan Pembelajaran Kooperatif Model Group Investigation Pada Mata Pelajaran IPS Geografi. Laporan Penelitian Tindakan Kelas. Universitas Negeri Padang.

Roh, K.H. (2003). *Problem-Based Learning in Mathematics.* [Online]. Available: http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=ED482725.

Sabandar, J. (2002). *Pembelajaran Geometry dengan Menggunakan CabryGeometri II*. *Jurnal Matematika atau Pembelajarannya* 3(10).

Sabandar, J. (2008). *Thinking Classroom dalam Pembelajaran Matematika diSekolah*. Bandung.

Seng, T.O. (2000). *Thinking Skills, Creativity and Problem-Based Learning*. [Online]. Available: http://pbl.tp.edu.sg/others/articles/%20on%others/TanOon Seng.doc.

Shannon, A.G. (2008). *Creative Thinking in Problem Solving*. [Online]. Available: http://unsw.edu.au/others/articles/Creative.pdf.

Silver, E.A. (1997). "Fostering *Creativity Through Instruction Rich in MathematicalProblem Solving and Problem Posing*." *ZDM: International Reviews on Mathematical Education (1997).* 29 (3), 75-80.

Sumarmo, U., et. al. (1998, 1999, 2000). *Pengembangan Model PembelajaranMatematika untuk meningkatkan Kemampuan Intelektual Tingkat Tinggi Siswa Sekolah Dasar*. Research Report. Bandung: Lembaga Penelitian.

Torrance, E.P. (1969). *Creativity What Research Says to the Teacher*. Washington DC: National Education Association.

Turmudi. (2009). *Landasan Filsafat dan Teori pembelajaran Matematika(Berparadigma Eksploratif dan Investigative).* Jakarta: PT. Leuser Cita Pustaka.

Univerrsity of Southern California. (2001). *Problem Based Learning*. Available: http://www.usc.edu/dept/education/science-edu/glosarryP.html.

Wahyudin. (2008). *Pembelajaran dan Model-model Pembelajaran: Pelengkapuntuk meningkatkan Kompetensi Pedagogis Para Guru dan Calon Guru Profesional.* Bandung: Diktat Perkuliahan UPI.