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Volume 2 No. 3 (Agustus 2022), Page: 147-156
E-ISSN : 2798-1428

THE EFFECTIVENESS OF THE CREATIVE PROBLEM SOLVING LEARNING MODEL IN TERMS OF STUDENTS' MATHEMATICAL REASONING AND COMMUNICATION SKILLS

Antonius KAP Simbolon

Universitas Prima Indonesia, Sumatera Utara, Indonesia

Email: antoniussimbolon8@gmail.com

Abstract
The purpose of this study is to describe the differences in the effectiveness of creative problem solving learning models and conventional learning models in terms of reasoning, communication, and self-esteem abilities. This research is a quasi-experimental research with a non-equivalent comparison group design. The research subjects were students at SMP Negeri 2 Tanjung Morawa. The sample consisted of 50 students from two class VII, each of which followed the conventional learning model and creative problem solving learning model. The research instrument consisted of a test of students' reasoning abilities and a test of students' mathematical communication skills. The analysis technique uses descriptive analysis and Hotteling's Trace. The results of the study at the 5% significance level showed that: (1) the creative problem solving learning model was effective in terms of students' mathematical reasoning and communication abilities; (2) the conventional learning model is effective in terms of students' mathematical reasoning and communication abilities; and (3) there is a difference in effectiveness between creative problem solving and conventional learning models in terms of students' mathematical reasoning and communication abilities.
Keywords: *Creative problem solving, reasoning ability, mathematical communication*

INTRODUCTION

Schools are educational institutions that were established to educate the nation's life. In schools taught various kinds of subjects that can provide provisions to help students in dealing with life. One of the important subjects in school is mathematics. Mathematics is an integrated science (NCTM, 2000, p. 64), which means that its parts are interconnected. The awareness that the parts of mathematics are interconnected is what needs to be instilled in students, so that mathematics can be understood as a whole as a unified whole. Mathematics as a science whose parts are related to each other is what inspires mathematical connections. This statement is in line with what has been expressed by Sugiman (2008, p.57) that mathematical connections are inspired because mathematics is not partitioned into various separate topics, but mathematics is a unity. Other abilities as learning outcomes achieved in mathematics learning are mathematical communication, mathematical reasoning, mathematical problem solving, mathematical connections, and mathematical representation (NCTM, 2000).

In general, reasoning is an activity or thought process to draw conclusions. Making a new statement that is true based on several statements also includes reasoning. Statements whose truth is shown by students being able to carry out activities to check patterns, record regularity, make assumptions about possible generalizations, evaluate conjectures, analyze and draw logical conclusions. Mathematical reasoning is defined as the thinking adopted to produce statements and reach conclusions on problem solving that is not always based on formal logic

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so it is not limited to evidence (Lithner, 2012). Mathematical reasoning is also an ability to analyze situations and construct an opinion (Kaur & Toh, 2012). Mathematical reasoning ability is the ability of students to be able to check patterns and regularities, take notes, analyze situations, draw logical conclusions, and evaluate conjectures.

Mathematical reasoning ability is very influential with the mathematics learning process that is followed by students. Students who have good reasoning abilities will easily understand mathematical material, and conversely students with low mathematical reasoning abilities will find it difficult to understand mathematical material (Tukaryanto, Hendikawati, & Nugroho, 2018). Mathematical reasoning ability is important and needed in learning mathematics because mathematics material and mathematical reasoning cannot be separated (Faradilah, 2014, p.113).

Thus, teachers should facilitate students to be able and accustomed to reasoning well in solving mathematical problems. However, the lowest average percentage achieved by Indonesian students in TIMSS is in the cognitive domain at the level of reasoning (Rosnawati, 2013, p.2). Though this reasoning ability is very important to construct the strategies used in solving the problems at hand. Low reasoning ability will result in students being less accustomed to constructing problem-solving questions that require them to reason.

Meanwhile, communication is a process of expressing mathematical ideas, verbal and visual understanding, and writing down numbers, symbols, pictures, graphs, diagrams and words. Communication is also a process of transferring information, understanding, and ideas from one person to another (NCTM, 2000). Communication is not only a process of carefully developing words but also a process of communicating ideas (Fox & Surtees, 2010, p.126). Students are expected to be able to communicate mathematical ideas with symbols, graphs, tables and diagrams or other things to clarify problems (National Education Standards Agency, 2006).

Someone who has good communication skills in expressing mathematical ideas or ideas tends to have a good understanding of the concepts being studied and is able to solve problems related to these concepts (Faradilah, 2014, p.113). Mathematical communication skills that need to be explored by students are directly proportional to the challenges of the problems in the questions. The higher the level of the question, the higher the communication skills required (Prayitno et al., 2013, p.388). Students' mathematical communication skills can be demonstrated through modeling, expression, writing, statements, and depictions (Kalaw, 2012, p.64).

The results of Shadiq's research (2007) show that the mathematical communication skills of Indonesian students are still not good, in several different areas, most students have difficulty solving problem solving problems and translating daily life problems into mathematical models. The weakness of students' communication skills is due to the fact that mathematics learning so far has not paid attention to the development of these abilities (Izzati, 2010). Therefore, efforts are needed to improve students' mathematical communication skills, as one of the cognitive aspects of learning outcomes in mathematics learning that is important to develop.

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Student learning outcomes in the mathematics learning process are influenced by several components, including the learning model, the role of teachers and students in learning, the way the teacher responds in learning, and the learning support system (Rahmawati & Suryanto, 2014). Learning model is a procedure used to determine learning outcomes. One of the learning models that can be used in learning mathematics is creative problem solving (CPS) and conventional learning models which are generally used in the classroom.

The design of the CPS learning model considers all the components contained in the meaning of the word. CPS is a process, method, or system to solve a problem with imagination or method and produce an effective treatment (Mitchell & Kowalik, 1999, p.4). The CPS learning model is a learning model that focuses on teaching and problem solving skills followed by strengthening skills (Supardi & Putri, 2010, p.574). CPS is a teaching method and a metacognitive strategy. Treffinger, Isaksen and Dorval (2011) say that CPS is not just problem solving. The creative aspect in CPS focuses on facing challenges as opportunities in dealing with unknown situations and productively managing tensions caused by the gap between future reality and actual reality.

The results show that the CPS process can develop students' ideas and can improve their creative thinking skills (Maharani et al., 2015, p.208). The CPS model is also able to construct knowledge by discussing it with a group of friends. In general, there are three main steps in CPS learning, namely fact finding, idea finding, and solution finding (Amali, Komariah, & Umar, 2015, p.2). In CPS learning, students are trained to develop intuition so that they are able to come up with many ideas in various alternative solutions to a problem. One of the advantages of the CPS learning model is that it stimulates the progress of students' thinking development to solve the problems they face quickly. That way, the CPS learning model can help improve reasoning because it is encouraged to be able to reason more quickly in solving problems (Tambunan, 2021, p.366).

The results of Muin's research (2018) show that the mathematical adaptive reasoning taught by the CPS model is higher than the mathematical adaptive reasoning skills of students who learn conventionally. Adaptive reasoning is reasoning that is more general than inductive and deductive reasoning. Furthermore, data regarding the effectiveness of the CPS learning model is needed in terms of mathematical reasoning, in this case it is reasoning that includes inductive and deductive reasoning, hereinafter referred to as mathematical reasoning. Previous research used the CPS learning model to improve students' problem-solving abilities, student activities and teacher's ability to manage learning (Udiyah and Pujiastutik, 2017: 544), self-concept (Purnamasari 2016:63), and HOTS (Herutomo and Masrianingsih, 2019 :197). Meanwhile, research on the CPS learning model on students' mathematical reasoning and communication skills has not been done much.

Based on this background, this study aims to describe the comparison of the effectiveness of the CPS and conventional learning models in terms of the aspects of students' mathematical reasoning and communication abilities. This research is expected to provide information about alternative learning models and also provide direct experience to researchers as mathematics teachers in applying effective learning models to students' mathematical reasoning and communication abilities.

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METHODS

The type of research used is a quasi-experimental research design using study groups that already exist in schools, namely classes that have been formed for learning activities. In this study, the CPS learning model and the conventional learning model were used. Conventional learning models are carried out with teachersprovide material in one direction to students. The research design used is non-equivalent comparison-group design.

The steps taken in this experimental research are the selection of two classes taken at random to determine the first group and the second group, then giving a pretest at almost the same time. Furthermore, providing learning treatment using the CPS learning model in the first group and conventional learning models in the second group. Next, give a posttest to both groups at the same time to determine the students' reasoning, communication, and self-esteem abilities. The items for the pretest and posttest are almost the same. This research was carried out starting April 2022, at SMP Negeri 2 Tanjung Morawa. The subjects in this study were students of class VII1 and VII2 at the school. The variables in this study are the independent variable (independent variable) and the dependent variable (the dependent variable). The independent variable is a learning model consisting of the CPS learning model and the conventional learning model.

CPS learning in this study was carried out in the following steps: 1) Mess finding, namely identifying situations that present challenges; 2) Data discovery, namely identifying all known facts related to the problem, to seek and identify information that is not known but is important for problem solving; 3) Problem finding, namely identifying all possible problem statements and isolating the most important or fundamental problems; 4) Idea discovery, namely identifying as many solutions as possible from the problem statement; 5) Solution search, namely using a list of selected criteria to select the best solution; and 6) Acceptance discovery, which is to make every effort to gain acceptance of the solution and determine the action plan and implement the solution.

Conventional learning in this study was carried out with the following steps: 1) The teacher conveyed the learning objectives to be achieved; 2) The teacher presents information to students step by step with the lecture method; 3) The teacher checks understanding and provides feedback; 4) The teacher checks the success of students and gives additional assignments to do at home; 5) The teacher provides further practice opportunities; and 6) The teacher gives additional tasks to do at home.

The data collection technique in this research is a written test in the form of a pretest (pretest) and a final test (posttest). The research instrument used is a test instrument in the form of a description that measures students' mathematical reasoning and communication abilities. The test was given to both groups. In preparing the test instrument, a grid of questions is first prepared. Furthermore, the preparation of questions, answer keys and guidelines for scoring each item is carried out. Before the test questions were used, the test items were assessed for validity and reliability. The test instrument was validated by an expert judgment technique consisting of two people. The test instrument was considered valid and declared fit for use after being revised. Some items were revised after getting input from experts. The results of the validity of each test item are well qualified.

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The results of the estimation of the reliability coefficient of the instrument of reasoning ability are 0.693 and the reliability of students' mathematical abilities is 0.725.

The data analysis technique used is descriptive analysis and inferential analysis. Descriptive analysis aims to describe the results of the learning process obtained before and after being given treatment related to students' mathematical reasoning and communication skills. The data presented consists of the mean, standard deviation, maximum and minimum values achieved. Meanwhile, inferential analysis aims to draw conclusions from the hypothesis. Inferential analysis is also used to statistically prove the proposed research hypothesis and answer the problem formulation that has been set.

Learning mathematics with CPS and conventional learning models is said to be effective in terms of reasoning, mathematical communication, and self-esteem, based on the minimum completeness criteria (KKM). Both learning models are said to be effective if the score meets the specified KKM, which is 70 or greater than 69.99. The decision criteria for rejecting the null hypothesis (Ho) with a confidence level $\alpha = 0.05$.

RESULTS AND DISCUSSIONS

The results showed an increase in students' mathematical reasoning abilities after participating in mathematics learning with the CPS model and in students with conventional learning. A description of the reasoning abilities of students in these two groups is presented in Table 1.

Table 1. Description of the reasoning data

Description	Cps class		Conventional class	
	Pretest	Posttest	Pretest	Posttest
Average	56	86	58	73
Standard deviation	7,65	6,84	11,75	12,65
Maximum score	70	95	65	92
Minimum score	35	70	30	30

Likewise with communication skills, there was an increase in the value of students' communication skills after participating in mathematics learning with the CPS model and in students with conventional learning. A description of the reasoning abilities of students in these two groups is presented in Table 2.

Table 2. Description of communication data

Description	Cps class		Conventional class	
	Pretest	Posttest	Pretest	Posttest
Average	58	89	55	73
Standard deviation	7,80	6,60	11,85	12,58
Maximum score	72	98	70	95
Minimum score	38	74	35	35

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Furthermore, the data analysis used is inferential statistical analysis. The data analyzed in inferential statistical analysis are data obtained before and after treatment. Prior to treatment, normality tests were carried out on both groups, namely those using the CPS and conventional learning models. This test was conducted to determine whether the distribution of data is normally distributed or not. The normality test used was a multivariate normality test using the mahalanobis distance test. The results of the normality test can be seen in Table 3.

Table 3. Test the normality of the pretest results for the initial conditions

Information	class	
	conventional	CPS
d2	82,25%	81,50%
category	Normal	Normal

The homogeneity test is intended to test the similarity of the variance-covariance matrix of the dependent variable simultaneously. Simultaneous homogeneity test results are 0.265 and are more than 0.05. This shows that the CPS and conventional learning model groups are homogeneous.

After treatment, normality test was performed on both groups. This test was conducted to determine whether the distribution of group data using the CPS and conventional learning models was normally distributed or not. The normality test used was a multivariate normality test using the mahalanobis distance test. The results can be seen in Table 4.

Table 4. Normality test of posttest results

Information	class	
	conventional	CPS
d2	82,55%	82,85%
category	Normal	Normal

In addition, homogeneity test was also carried out to test the similarity of the variance-covariance matrix of the dependent variable simultaneously. Simultaneous homogeneity test results obtained at 0.275 and a value of more than 0.05. This shows that the CPS and conventional learning model groups are homogeneous.

To see the effectiveness of the CPS learning model in terms of students' mathematical reasoning and communication abilities, a multivariate analysis of the Manova test was carried out. The multivariate test results show that the Sig Hottelling's Trace value is 0.000. This means that H0 is rejected and H1 is accepted. This shows that the CPS learning model is effective in terms of students' mathematical reasoning and communication abilities.

Furthermore, to see the effectiveness of the conventional learning model in terms of students' mathematical reasoning and communication abilities, multivariate analysis of the Manova test was carried out. The multivariate test results show that the Sig Hottelling's Trace value is 0.000. This means that H0 is rejected and H1 is accepted. This shows that the CPS learning model is effective in terms of students' mathematical reasoning and communication abilities.

The test of differences in the effectiveness of the learning model in terms of students' mathematical reasoning and communication abilities was carried out by using the two group manova test. Based on the results of the analysis, the value of Sig Hottelling's Trace is 0.000. Based on the test results, it can be concluded that there are differences between the CPS and conventional learning models in terms

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of reasoning, communication, and self-esteem abilities.

By designing a learning model in accordance with instructional design and empirical studies, it will provide a framework for developing effective learning guidelines (Khalil & Elkhider, 2016). This shows that the learning model affects student learning outcomes (Kauffman, 2015; Nurlaela et al., 2018). Based on the description of the research data, the average student learning outcomes with the CPS learning model tend to be better than conventional learning. This is possible because the CPS learning design provides contextual problems that strongly encourage the accommodation of mathematical reasoning and communication skills, as well as creative challenges to create various problem-solving solutions so as to develop thinking skills (Sophonhiranraka et al., 2015).

This study shows that there are differences between the CPS model and the conventional model in terms of students' mathematical reasoning and communication abilities. To see the effectiveness of the CPS and conventional learning models on students' mathematical reasoning and communication abilities, the Manova test was carried out which showed the Sig Hotelling's Trace value of 0.000. This means that there are differences in the effectiveness of the CPS and conventional learning models on students' reasoning abilities, communication skills, and self-esteem. The indicators assessed in the study were in the form of expressing ideas through writing or verbally or in pictures, answering questions and asking questions.

In the CPS learning model, students are directed to learn actively and in groups. The application of the CPS learning model can improve student learning outcomes and activeness (Kusumaningrum, 2009, p.99). This group activity certainly has a good impact on increasing students' self-esteem. Various perceptions of different answers in groups will encourage students to learn from each other. In addition, group activities will also support the process of self-assessment, emotional control, and self-competency evaluation. This is in accordance with the research of Maharani et al. (2015, p.214) that the interactive CD-assisted creative problem solving learning model can improve students' creative thinking about prism and pyramid material. Based on the responses of students and teachers, the learning model produces practical and positive learning.

Based on the results of data analysis, learning with the application of the CPS model can improve students' communication skills. This is in accordance with research conducted by Widiatmika, Suharta and Suryawan (2019, p.7). The improvement in communication skills in the study was seen from the students' learning mastery which had increased from each learning meeting. This mathematical communication ability is important because mathematics is not only a thinking tool that helps students to develop patterns, solve problems and draw conclusions but also as a tool to communicate thoughts, ideas, ideas clearly, precisely and briefly (Yuniarti, 2014: 114).

Learning with the application of creative problem solving models is effective for improving reasoning and mathematical communication skills. This is in accordance with research conducted by Tambunan (2021, p.371) which states that learning using creative problem solving learning models is more effective in improving students' mathematical reasoning and communication skills. The results of this study are also consistent with Nopitasar's research (2016:103) which found that the adaptive mathematical reasoning ability with CPS was

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higher than the mathematical adaptive reasoning ability of students who were taught with conventional learning. The problems presented in this CPS model require students to demonstrate a method of proof through a problem-solving approach that is solved by imagination and innovation (CEF, 2015, p.8).

CONCLUSIONS & RECOMMENDATIONS

Based on the results of the study, it can be concluded that: 1) The creative problem solving learning model is effective in terms of students' mathematical reasoning and communication abilities; 2) The conventional learning model is effective in terms of students' mathematical reasoning and communication abilities; and (3) there is a difference in effectiveness between creative problem solving and conventional learning models in terms of students' mathematical reasoning and communication abilities. Therefore, the use of learning models can be used according to the needs and expected goals. As a follow-up to this research, it is necessary to investigate the effectiveness of the CPS and conventional learning models on the subject matter and other dependent variables.

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