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THE EFFECTIVENESS OF COOPERATIVE LEARNING IN THE COURSE OF MATHEMATIC PROBLEM SOLVING

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ABSTRACT

Problems in mathematics are a challenge that needs solving but the solution cannot be done by using routine procedures. Understanding the problem as well as wealth of experience and strategy is needed to solve these problems. Students need experiences that can be obtained through interaction with others in cooperative learning. Different strategies that may emerge from others can enrich their experiences. The study was conducted to determine the effectiveness of cooperative learning in mathematics problem solving courses. The research method used is descriptive qualitative research methods. The object of research is the effectiveness of group learning in mathematics problem solving courses which include four procedures: understanding problems, planning strategies, solving, and checking answers. The research subjects are fifth semester students of PGSD STKIP PGRI Pacitan study program in the academic year 2019/2020. Sources of data in this study are: (1) Mathematical problem solving test data (2) Observation data during the lecture process (3) Group learning questionnaire data. Test of validity of the data is done through triangulation technique. The results showed that group learning in mathematics problem solving courses had fulfilled the characteristics of cooperative learning, providing benefits to students. And the effectiveness of four mathematical problem-solving procedures resulted in 80% for problem understanding, 80% for strategic planning, 70% for solving math problems, and 75% for checking math problem solving.

Keywords*: mathematical problem solving; cooperative learning; mathematics.*

INTRODUCTION

Problems are part of humans' life. As long as they live, they must have experienced problems which can become obstacle to their progress if they cannot be resolved in an appropriate manner. Every individual has a different way of solving problems. Problems encountered are not to be avoided, but must be resolved, because problems will not disappear if they are not resolved (Wahyudi, 2017: 1).

Problems that develop will certainly be more complex along with the development of science and technology. This development requires problem-solving competencies for each individual. One of the supporting factors needed to solve human problems is mathematical problem solving skills. Therefore, solving mathematical problems is an important skill for every individual to master.

Learning problem solving in school and college is expected to be able to equip individuals to solve problems that will be encountered in everyday life. Individuals will be able to solve mathematical problems when they understand and master the concepts and properties of arithmetic operations. This is because most of the content of mathematics is the concept of counting numbers. Understanding this concept is the basis for being able to solve mathematical problems.

Understanding the concepts and numeracy skills are not the only things needed to solve math problems. Understanding the problems is another very important thing that will be the starting point in solving a problem. Furthermore, proper procedures and accurate strategies are the next important thing in solving math problems. These things are needed together with the support of a correct understanding of mathematical concepts and adequate arithmetic or computing skills.

Each individual's problem is different from others. However, because humans are unique creatures, it is certain that each individual human being will have a different way of solving a problem that may be the same. Because every individual has a different strategy, it will be a wealth of strategy when someone is able to adopt many different strategies from others in solving one problem. Therefore, experience, interaction with other people, and exchanging opinions or information about mathematical problems will lead to the enrichment of mathematical problem solving strategies and skills. This is what is called cooperative learning, which is learning with an element of collaboration with other people. The cooperative learning system will be able to support the enrichment of strategies and mathematical problem solving skills.

Learning emphasizes more on students as creatures who realize and understand the need to interact with the environment. Silberman (2011: 30) explains that one way to meet the need to interact with the environment is to build relationships with other people and become part of a group. The feeling of belonging to each other in the group can strengthen students to face challenges. When they learn together, emotional and intellectual support arises that allow them to exceed the threshold of initial knowledge and skills.

Cooperative learning in tertiary institutions, especially at STKIP PGRI Pacitan, has not been widely implemented according to procedures. Although there are several courses that use the group presentation method, in practice, it is not uncommon for the presentation material to be prepared by one individual only, and then presented in the class in groups.

The implementation of cooperative learning like that is certainly not perfect. Ideally, cooperative learning is carried out through active discussion stages, exchanging information with each other, and cooperation among group members to complete assigned tasks by helping each other so that mutually beneficial activities occur among group members and there is a common understanding among the members of the group. The implementation of

cooperative learning in accordance with this procedure will make each individual feel the benefits of group learning.

Nurhadi (2004: 112) states that the cooperative learning model is a learning approach that focuses on using small groups of students to work together in maximizing learning conditions in order to achieve learning goals. Most involve students in groups of four students with varying abilities. The characteristics of cooperative learning according to Isjoni (2009: 62) are the roles of each member, direct interaction between students, each member's responsibility for their learning method and also their group friends, the teacher's help in developing personal group skills, and the teacher's interactions with group when needed.

Mathematical problem-solving course is part of curriculum structure in Primary School Teacher Education Study Program at STKIP (Teacher Education and Pedagogy College) PGRI Pacitan. This course appears in the odd semester, which is the fifth semester of the current academic year. By considering the previous description that solving mathematical problems requires understanding, computational skills, appropriate procedures and strategies, and high creativity, it has also been revealed that cooperative learning is superior to individual learning by contributing to the enrichment of individual problem solving strategies and skills. concerned, the implementation of mathematics problem solving lectures at STKIP PGRI Pacitan is carried out by following the procedures and characteristics of cooperative learning.

The implementation of cooperative learning in problem solving courses is carried out through active discussion stage, exchanging information with each other, cooperation between group members to complete the assigned tasks by helping each other so that mutually beneficial activities occur between group members and understanding among the group members. The implementation of cooperative learning in this mathematics problem solving course can be seen from its effectiveness after running for one semester.

Cooperative learning is a social-based learning and according to Anita Lie, this learning model is based on homo homini socius which is contrary to Darwin's theory. This philosophy emphasizes that humans are social creatures. Interactive dialogue or social interaction in learning is very necessary. Thus, cooperation is a very important requirement for survival, including in the learning process. Group learning can be categorized as cooperative learning if it is able to promote: (a) positive interdependence; (b) personal responsibility; (c) promotional interaction (face to face interactive promotion); (d) communication between members (interpersonal skills); and (e) group processing (Supriyono, 2011: 56-58). From some of the definitions and characteristics above, it can be concluded that cooperative learning is learning that involves students in small groups helping each other in learning, there is direct interaction, communication between group members, group processing, and individual responsibility.

Robert (Jihad and Haris, 2008: 14) states that learning with conditions like the one above is effective learning because the students can acquire specific skills, knowledge and attitudes. In other words, learning is effective when there are changes in cognitive, affective, and psychomotor aspects.

Among benefits of implementing cooperative learning according to the results of research by Morgan et al. (2005) is that students become active in solving mathematical problems. Even lazy students who previously did not work begin to participate in the problem-solving process. They are also more motivated to work together in groups than to compete individually. They prioritize curiosity in the process of finding the correct answer rather than simply getting the right answer, the teacher values each student's abilities more by involving each student in group discussions.

Problem-solving ability is one aspect of the ability that is important in learning mathematics. The usefulness and power of mathematics will be very limited if there is no problem solving ability. This is stated by NCTM (2000: 182) "Problem solving is the cornerstone of school mathematics. Without the ability to solve problems, the usefulness and power of mathematical ideas, knowledge, and skills are severely limited."

Problem solving also serves as a means of learning about other mathematical ideas and skills. "Problem solving is also important because it can serve as a vehicle for learning new mathematical ideas and skills" (Schroeder & Lester in NCTM 2000: 182). This statement means that through problem solving students will be facilitated to explore more information, ideas, and mathematical skills.

In line with this, the results of research by Hino (2007: 1) in Japan showed that problem solving has the advantage of being able to stimulate efforts to develop material. Pimta, Tayruakham, & Nuangchalem (2009: 381) also stated that problem solving affects the development of thinking skills methods, "*problem solving is considered as the heart of mathematical learning because the skill is not only for learning the subject but it emphasizes on developing thinking. skill method as well*."

Each person has different problems from the others. It depends on who is facing the problem. If he or she can solve a problem immediately then that problem cannot be called a problem. A problem is a problem if the answer to it cannot be immediately found with certain rules or laws (Endang Setyo Winarni & Sri Harmini, 2011: 115). Furthermore, Musser, Burger, & Peterson explained that doing exercises is a very valuable aid in learning mathematics. "*Doing exercises is very valuable aid in learning mathematics. Exercises help you to learn concepts, properties, procedures, and so on which you can then apply when solving problems*" (Musser, Burger, & Peterson, 2011: 4).

Activity in solving problems means taking an action. This is as expressed by Polya (1962: 117) "to solve a problem means to find such action". Kruse (2009: 2) states that a problem requires someone to act and respond, "*problem requires us to act. They require us to respond, to figure out the step and actions we will take*." If the problem is structured well, someone will be able to clearly determine how or action to solve it. "*If your profile is well-structured, you would have clear idea of how to solve it*" (Van Goundy, 2015: 22).

In essence, problem solving involves three important and fundamental skills, namely the skills to translate questions, the skills to choose strategies, and the skills to operate numbers (Runtukahu & Kandou, 2014: 194-201). These three skills really support the problem-solving process. Polya divides the troubleshooting steps into four procedures. The procedure is to understand the problem, plan strategies, implement strategies and review them (Polya, 1973: 5-6).

The first step is "to understand the problems," which is to formulate what to look for and what data is available. Billstein, (2014: 3) adds several things that can help understand the problem, including simplifying the questions, identifying what you want to find, and organizing the information obtained from the questions.

The second step, "plan a solution" is choosing a strategy. Burton et al., 1994: xx, "choose one of these strategies: guess and check, draw a picture, make a model, act out the problem, make a table, chart, or graph, write a number sentence". The strategy chosen is adjusted to the facts of the problem, how the problem can be solved with one or more existing strategies.

The third step, "solve the problem", is a step taken by solving the problem after determining the technique to be used. Computations carried out in this step can be by manipulating objects or using several other computational options, including using scribbles

or written computation (paper and pencil), mental math (mental computation), and calculator (Burton et al., 1994: xxi).

The fourth step is “to look back and check for solutions or answers.” This step is done by answering the questions "how can I check the answer" and "whether my answer has answered what was asked". A person can be wrong in solving especially if the arguments or statements in the problem are long. This is as expressed by Polya (1973: 15) in his book “Thus, he should have good reasons to believe that the solutions are correct. Nevertheless, errors are always possible, especially if the argument is long and involved. Hence, verification is desirable."

Problem solving is a practical skill. Practical skills are acquired through practice and imitation or imitation. This is stated by Polya (1973: 5), "*solving problems is a practical skill .... We acquire practical any skill by imitation and practice*”. Furthermore, Polya stated that someone who is trying to solve a problem needs to observe and imitate what other people do when solving problems, therefore group learning settings can support a person to more easily imitate what other people in the group are doing in solving math problems, in addition to very possible for discussion and exchange of ideas.

Indicators for measuring mathematical problem solving abilities as expressed by Souviney (1994: 16) by adapting from the Curriculum and Evaluation Standards for School Mathematics are: 1) the ability to formulate problems (formulate problems); 2) implementing various strategies to solve problems (apply a variety of strategies to solve problems); 3) solve problems / find solutions (solve problems); 4) verify / check and interpret the results according to the initial problem (verify and interpret results).

RESEARCH METHOD

Research Design

This type of research is a qualitative descriptive study. Data analysis is described in the form of descriptions or qualitative descriptions that explain the implementation of cooperative learning and the effectiveness of cooperative learning in solving mathematical problems. The description of the effectiveness of cooperative learning in solving mathematical problems will be seen from the point of view of four mathematical problem solving procedures which include understanding problems, planning solutions, implementing solutions and checking the results of solving.

Participant

This research was conducted at STKIP PGRI Pacitan, the research subjects were fifth semester students of the PGSD Study Program of STKIP PGRI Pacitan in the academic year 2019/2020.

Data Collection

Data collection techniques using documentation techniques, observation, questionnaires, and tests. The documentation technique is carried out in the initial study to the final stage of the research. Documentation is related to data about the implementation of cooperative learning in mathematics problem solving courses and documentation of mathematics problem solving test results. The documents collected are photos of learning activities, as well as test answer sheets (middle semester test) for solving math problems in the odd semester of the 2019/2020 academic year.

Observations were carried out in a participatory manner where the researcher was involved in learning activities. Thus, the observer (researcher) fully understands the real

conditions (real) which are carried out in group learning activities in mathematics problem solving courses. The questionnaire was used to explore data about the implementation of cooperative learning and reinforcement data to determine the effectiveness of cooperative learning in mathematics problem solving courses. While the test was conducted to obtain data on the effectiveness of cooperative learning in problem understanding procedures, problem solving planning, problem solving implementation, and problem solving results checking.

Data Analysis

The data validity test was carried out through technical triangulation, namely matching research data back based on different data collection techniques, namely by using documentation, observation, questionnaires and tests. The data analysis technique used is qualitative, using descriptive descriptions based on the findings of data that have been collected through the stages of reducing the collected data, describing the data based on the categories, writing the researchers' thoughts based on the results of observations made, linking the discussion with the theory that has been cited and linking the results research by theory.

RESULTS AND DISCUSSION

Implementation of Group Learning

At the initial meeting (phase 1), the class was divided into 5 study groups, with members of each group ranging from 6-7 people. Group members are determined randomly by counting. Each group consists of men and women with various abilities. The agreement made and the rules for each mathematics problem solving lecture is that each week / meeting each group reads and discusses the same material together, then continues by solving the existing problems after the material together as well. Thus, there are no students who missed the material, because all class members study the material simultaneously at every meeting. Problem solving involves group members by discussing and teaching each other and sharing information. The role of the lecturer in phase 1 is to help during the discussion process, get around, monitor and help if there are difficulties, as well as provide a trigger for students if there are difficulties in understanding problems or developing problem-solving strategies.

The next meeting (phase 2) begins with determining the discussion group by means of a lottery. The group selected as discussants is in charge of discussing the problem in the chapter being studied at that time. The discussion begins with working on the problem by members of the non-discussing group (who is not in charge as discussants), thus, each individual and also each group has the same sense of responsibility to be able to solve the material and solve existing problems. The role of the lecturer here is to provide corrections (conclude whether or not the discussion given by the discussion group is true) or even a completely different answer if the discussion group does not have an answer or the answer given is wrong. The implementation of group learning in mathematics problem solving courses is carried out with the procedure as shown in the figure below:

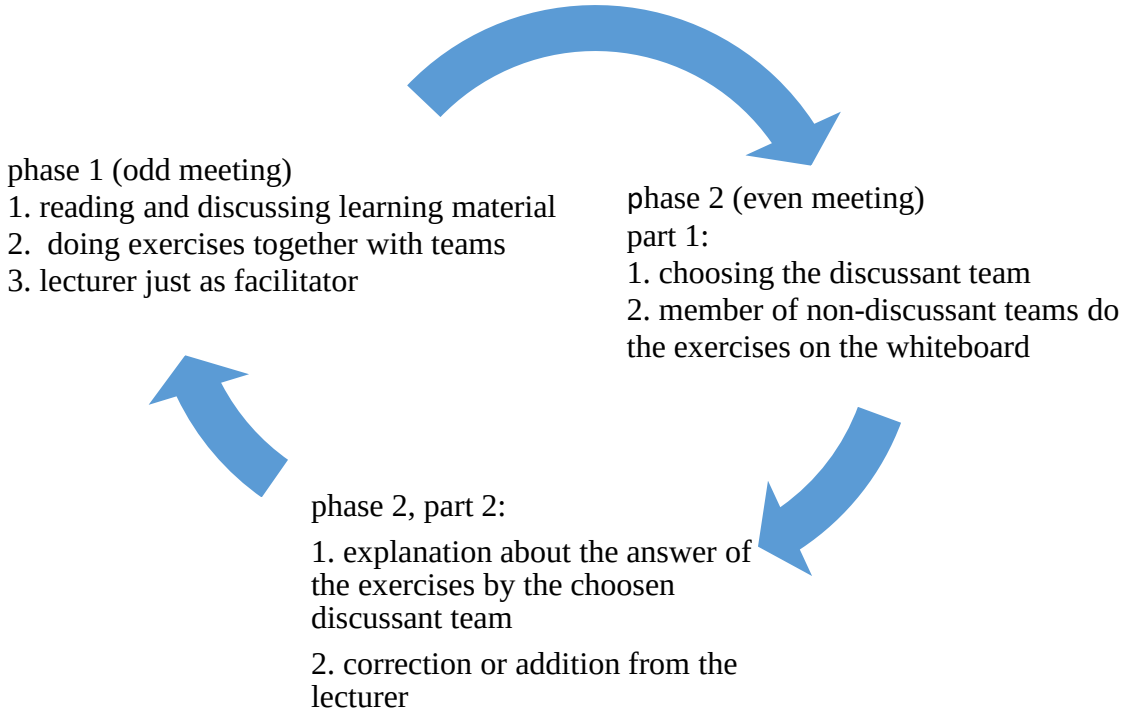

Figure 1. Group Learning Phase in Problem Solving

When viewed from the learning process in the problem solving course, this learning has fulfilled the cooperative learning category as expressed by Roger and David (Supriyono 2011: 58), which fulfills:

a) There is positive interdependence
b) There is individual responsibility (personal responsibility)
c) There is a promotional interaction (face to face interactive promotion)
d) There is communication between members (interpersonal skills)
e) There is group processing (group processing).

In addition, the learning process in problem solving also has the characteristics of cooperative learning as conveyed by Isjoni (2009: 62), namely that each member has a role, there is direct interaction between students, each member of the group is responsible for their learning method and also their group friends. , the teacher helps develop personal group skills, the teacher only interacts with the group when needed.

Student Response to Cooperative Learning

To ensure that cooperative learning runs properly, the researcher distributes a questionnaire to gather information about the conditions of each group during the group learning process. The questionnaire question is about the group learning process whether it has gone through the proper phases, namely the discussion starting from reading the material or not, whether group members are actively involved in discussions and cooperation or not, and whether or not there are benefits from learning with grouping system like this.

The student response to the questionnaire that was distributed was that some groups started the discussion by reading the material and writing down the important points of the material, but there were also some who immediately tried to work on the questions. Based on the results of the researchers' observations, this condition does occur, some students prefer to work on questions by skipping the reading phase of the material. In cases like this, the

lecturer takes advantage of the moment when students ask questions about questions that cannot be done by the student by asking whether the students have read the material or not, because the questions being asked are similar to the examples written in the material. With questions and notifications like that, it can make students aware that reading the material is important, because they will be able to gain knowledge that can be the initial provision for doing questions.

The conditions for the group that did not skip the reading phase at the beginning looked different. Some students seemed to note the main points or important points of the material they read.

Most students have also been actively involved in the group discussion process. Most groups have experienced interaction between members, checking with each other and exchanging information. Discussions are livelier in problem solving because there is something more challenging in the problem. Even though at the beginning of the process, the questions were divided individually with the intention of reducing the burden on the group, at the end there was always a discussion among the group members and all students had notes on their completion.

Students also feel the advantage of this group study in understanding the material, they can get teaching from their friends, in working on lighter questions because they are done together, in tests it also helps because they still remember explanations from friends both from discussion and discussion of questions. Even so, some students also admitted that the explanation from friends during the discussion was sometimes still not in depth.

By paying attention to this description, it turns out that group learning provides several advantages that are not obtained from individual learning. This is consistent with the theory of research by Morgan et al. (2005) is that students become active in solving mathematical problems. Lazy students who previously did not work begin to participate in the problem-solving process. Students are also more motivated to work together in groups than to compete individually. Students prioritize curiosity and the process of finding the correct answer rather than just getting the right answer right away, and teachers value each student's ability more by involving each student in group discussions.

Robert (Jihad and Haris, 2008: 14) states that learning with conditions like the one above is effective learning, where by learning students acquire specific skills, knowledge and attitudes. In other words, learning is effective when there are changes in cognitive, affective, and psychomotor aspects.

Mathematical Problem Solving Test Results Understanding of the Problem

The first step in understanding the problem is defining what to look for and what data is available. Some of the things done are simplifying the questions, identifying what you want to find, and organizing the information obtained from the questions (Billstein, 2014: 3). Some things that must be considered include, whether it is unknown, what data is given, is it possible that the condition is stated in the form of an equation or other relationship, whether the given condition is sufficient to find what is being asked, whether the condition is excessive or contradictory, draws or writes. the appropriate notation (Wahyudi, 2017: 18).

Understanding of mathematical problems can be seen from students' descriptions in writing what is known (the data provided) in the form of sentence descriptions, mathematical equations or relationships, pictures or other forms and descriptions of what is being asked (what is not known). All of the information needed for the work is written down, and unnecessary information (excessive or conflicting conditions) is left out. If the information or

conditions provided are not sufficient to find what is being asked, students can process the existing data to find the additional data needed.

The results of the problem-solving test showed that most of the students, namely about 85% of them, were able to correctly write down what they knew and what was asked from the questions. Of the 4 math problem solving test questions, the average student can write down what they know and ask about the questions. In test question number 1 about finding the difference between two natural numbers which adds up the result is 28 and if multiplied the result is 192 all students can write what is known and what is asked correctly.

In question number 2 about finding the area of a flat shape contained in a wider flat shape, using several strategies, as many as 3% or 2 students wrote what was asked of the questions with a few errors, namely incomplete writing information. In addition, 20% or 14 students during the process failed to find the shape in question, even though when writing down what was asked was correct. For example, it has been written that what is being asked is the area of DOC, but students still write down the area of the ABCD rectangle, the area of BOC, or the area of ADO without using these areas to find the area of DOC.

In question number 3 about finding the length of the base and height of the triangle with the area and the relationship between the length of the base and the known height of 3% or 2 students write what is known with a slight error, namely incomplete information, which should be written the base length = 4/3 x height of the triangle or a = 4/3 xt, only the base length of 4/3 is written. In this problem, as many as 21% or 15 of the students were trapped in wrongly substituting the base length value when entering the completion stage.

Question number 4: “How many possibilities will someone get in changing Rp. 70,000.00 which was exchanged for Rp. 1,000.00; Rp. 5,000.00; Rp. 10,000.00; Rp. 20,000.00. Money denominations may be more than one ”. In this question, many students were incomplete in writing down information, namely that the fractions of money that had to be exchanged were not written down. There are approximately 15% or about 10 students who make this mistake. Thus it can be concluded that the effectiveness of group learning in understanding mathematics problems is around 80%.

Settlement Strategy Planning

The second step is to choose a strategy. The strategy chosen is adjusted to the facts of the problem, how the problem can be solved with one of the existing strategies. "Choose one of these strategies: guess and check, draw a picture, make a model, act out the problem, make a table, chart, or graph, write a number sentence" (Burton et al., 1994: xx).

In this step, students have been able to choose a strategy in accordance with the existing questions. Of the four questions, each one has its own strategy that best fits the type of problem. There are also those that in one problem can be done with two different strategies. For example question number 1, where students are asked to find two numbers which add up to 28 and multiply the result 192. In this question, you can do it with a guess and check strategy and you can also list all the possibilities that exist. Both of these methods have been used by students.

Meanwhile, in solving problem number 3 which contains the area of a flat shape, students choose a strategy using a formula. some students experienced errors in writing formulas, some were lacking in writing formulas, there was also a fatal error in writing formulas. The average error of the formula occurs in problem number 3 which is related to the area of the triangle and also number 2 related to the area of the trapezoid shape, where to find the area of the DOC, you can use the area of the trapezium DCBO minus the area of the COB triangle.

In addition to formulas, strategic errors also occur in question number 2, namely to find the area of DOC in a variety of different ways, students experience errors in determining the relationship between shapes, even students do not know what strategy to use to determine the area of the shape so that just write down the area of all the shapes. Solving problem number 2 requires physical manipulation to provide a real picture of the parts of the existing shapes and the relationships between these shapes.

If converted into percent, there are approximately 20% of students or around 14 students who are still unable to plan the completion strategy well. Thus it can be concluded that the effectiveness of group learning in planning math problem solving strategies is around 80%.

Problem Solving

Things that must be considered in the third step or the problem solving stage are checking each step whether it is correct or not and how to prove that the steps chosen are correct (Wahyudi, 2017: 19). Computations carried out in this step can be by manipulating objects or using several other computational options, either with scribbles (paper and pencil), mental computation (mental math), or using a calculator (Burton et al., 1994: xxi). Most of the students have been able to solve the problem well. However, there are still around 20 students or 30% of the total number of students who are still unable to carry out this third stage properly.

The most common error occurs in number 3, namely when determining the length of the base of the triangle and the height of the triangle. There is a division operation with a fraction which should be in the form of multiplication by inverse but students do not do it like that. In question number 3, there were also many students who were wrong in substituting the values for the length of the base of the triangle and the area of the triangle. This number is also inaccurate in determining the results, for example there is actually still one step that must be done but students have considered it completed and not continued.

There are also many computational errors in question number 4, namely in the case of money changers. Many of the money denominations written by the students were wrong and by not checking in the fourth step, the students' answers remained wrong. In questions 1 and 2 there is also a slight error in calculating the results of multiplication, addition and subtraction. Thus it can be concluded that the effectiveness of group learning in problem solving is 70%.

Answer Checking

The fourth step is "look back and check the solution". This step is done by answering the questions "how can I check my answer" and "does my solution answer the question". This fourth step needs to be done so that someone has a strong reason or believes that the problem solving done is correct (Polya, 1973: 15). In this fourth step, the process and results are checked again, as well as their suitability with the question request.

The checking stage in solving math problems is still rarely done by students when doing tests. Of the total number of 79 students, there are around 25% or 20 students who missed or did not take this step. The checking stage is very necessary, especially in working on question number 4 about money exchange. Some students who missed the check wrote wrong answers because students did not recalculate the total number of fractions they wrote down.

A small number also made mistakes in question number 1, namely because they missed the checking stage, some students wrote wrong answers related to two numbers which

add up to 28 and multiply it to produce 192. While a small proportion of students (2 people) did a check on the work of number questions. 3 about the area of the triangle. So these 2 students enter the values for the length of the base and the height of the triangle they get into the area formula for the triangle to make sure their answers are correct. Things like this should be done by all students so as to minimize errors in providing solutions. Thus it can be concluded that the effectiveness of group learning in checking completion is 75%. The results of the math problem solving test can be seen in Table 1 below:

Table 1. Data on Concept Understanding Test Results

Problem Solving Procedure	Achievement level
Understand / understanding the problem	80% able to understand the problem well
Plan / planning completion	80% able to plan the right strategy
Do / problem solving	70% are able to solve the problem well
Check / check results	75% have checked the process and answers well

CONCLUSION AND RECOMMENDATION

Based on the research results, it is known that the implementation of group learning in mathematics problem solving courses has met the cooperative learning categories; which are: (a) positive interdependence; (b) personal responsibility; (c) promotional interaction (face to face interactive promotion); (d) communication between members (interpersonal skills); (e) Group processing. In addition, the learning process in solving this problem also has the characteristics of cooperative learning, namely that each member has a role, there is direct interaction between students, each member of the group is responsible for his learning method and also his group mates, the teacher helps develop personal group skills, the teacher only interacts with the group when needed / needed. The effectiveness of group learning is 85% effective for problem understanding, 80% effective for strategic planning, 70% effective for problem solving, and 75% effective for checking answer.

Recommendations for further research are that research on cooperative learning should be applied to other mathematics courses, for example high-grade mathematics education courses or others. That is because of cooperative learning is rarely applied to mathematics learning.

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