

Undergraduate Student's High Order Mathematical Thinking Abilities Through Lesson Study Activities

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Abstract—The purpose of this research is to develop lesson study learning activities aiming to improve undergraduate students' high order mathematical thinking abilities. This paper is intended to describe the learning activity-based on lesson study to improve student mathematical communication and problem solving ability. This research involved 36 students who take analytic geometry courses. This research is done by using the steps in activity-based on lesson study. Implementation of the research took place in four cycles. Each cycle consisting of activities plan, do and see. The instrument used are the observation sheet, instructional videotape, student worksheets, test for mathematical problem solving and communication ability. Analysis on data revealed that the undergraduate students' high order thinking ability especially in mathematical problem solving and mathematical communication increased significantly. By analysis, undergraduate students' mathematical problem solving, and mathematical communication ability was categorized good. Students already have the ability to analyze a given problem and make a plan how to solve the problem and then solve it as planned. Completion obtained through reflected in the classroom discussions.

Keywords: *mathematical communication, mathematical problem solving, lesson study*

I. INTRODUCTION

Issues concerning about mathematical thinking are one of the fundamental goals of mathematics curricula and instruction. One of the ability that need to be mastered mathematics student teachers is mathematical problem solving ability. According to NCTM [1] standard for mathematical problem solving ability mathematical learning programs should enable students to: build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; implement and customize a variety of appropriate strategies to solve problems; and monitor and reflect on the process of problem solving in mathematics. Solving ability is an integral part of learning mathematics. As noted Ruseffendi[2] that the problem-solving ability in mathematics is essential, not only for students who would later explore or learn math, but also for students who will apply it in other areas of study and in everyday life.

Besides having the mathematical problem-solving ability, of students should also be able to communicate mathematical ideas student had verbally and in writing, students must be able to interpret and evaluate the problems that arise so as to obtain the appropriate trouble shooting. Capabilities that support mathematical problem solving ability is called mathematical communication skills. So in order to become a perfect problem solver, student must have good mathematical communication

Students will have good ability to problem-solving and mathematical communication if both of these capabilities are continuously trained on learning activities in the classroom. The quality of learning that can facilitate to develop students' ability and can be done with the planning, implementation and evaluation of learning activities in a sustainable manner. One way of improving the quality of continuous learning is by conducting lesson study. Lesson study is an approach to improve the quality of learning that applies the concept of learning communities from each other to increase knowledge. Events

Calendar[3] defines the lesson study as a method of analysis of the case in practice learning, which aims to help the professional development of teachers and lecturers as well as an opportunity for teachers to learn from each other through the learning activities in the classroom. In lesson study activities, teachers can use a variety of learning models that correspond to the learning material or conditions that will be done. One of these is the model of learning problem-based learning.

A. *Mathematical Problem Solving*

Intellectual abilities are classified based on the level of complexity and is composed of the simplest mental operations to the most complex level. Problem solving is one type of intellectual skill rank higher and more complex than other types of intellectual. According to Kirkley [4] mathematical problem solving involves higher level thinking skills such as visualization, association, reasoning, manipulation, abstraction, analysis, synthesis, and generalization. The term “problem solving” refers to mathematical tasks that have the potential to provide intellectual challenges for enhancing students’ mathematical understanding and development. NCTM [1] stated that problem solving as a process that encompasses the entire process of teaching-learning provides skills about a contextual concepts.

Solving problems involving varying contexts derived from the linking problems in daily life situations posed mathematics. Students can solve some of the problems posed to them by others. However, it is easier for them to formulate their own problems based on personal experience and interest. The importance of problem solving ability, namely: (1) the ability of problem solving is a general purpose teaching of mathematics, even as the heart of mathematics, (2) solving the problem can include methods, procedures and strategies or ways used is a core process and major in mathematics curriculum, and (3) solving the basic skills in learning mathematics. Through problem solving, students will have the basic capabilities that are more meaningful in thinking, and can make strategies for the completion of further problems. Polya [5] describes in detail the four steps in solving problems, which are presented in sequence, namely: (1) understanding the problem (2) devising a plan (planned completion), (3) carrying out the plan (implement the plan), and (4) looking back (to re-examine the process and outcomes).

For the purposes of this study is a mathematical problem-solving ability is the ability to identify the elements that are known, asked, and the adequacy of the required elements; able to make/prepare mathematical models; can choose and develop coping strategies; able to explain and verify the answers obtained. To measure the ability of solving mathematical problems required several indicators. In this study, to measure the ability of students' mathematical problem solving test given in the form of questions about the material being taught. According to Turmudi [6] The indicator shows the mathematical problem-solving ability in this study are as follows.

1. Demonstrate understanding of the problem, including the ability to identify the elements that are known, asked, and the adequacy of the required elements.
2. Ability to create/construct a mathematical model, includes the ability to formulate problems of everyday situations in mathematics.
3. Select and develop coping strategies, including the ability raises various possibilities or alternative means of solving formulas or knowledge which can be used in solving the problem.
4. Able to explain and verify the answers obtained, including the ability to identify errors of calculation, the use of a formula error, check the compatibility between that have been found with what is being asked, and can explain the truth answers.

B. *Mathematical Communication*

Hulukati [7] said mathematical communication refers to the ability to use mathematical language to express mathematical idea and arguments precisely, concisely and logically. It helps students develop their own understanding of mathematics and sharpen their mathematical thinking. Mathematical problems solving that have been discussed previously closely related to mathematical communication. Students who already have mathematical problem solving ability are required also to be able to communicate, so that understanding can be used by others. With the students' mathematical communication skills can also take advantage of the mathematical concepts that are already understood others. By communicating

mathematical ideas to others, one can improve mathematical understanding. Huggins[6] that in order to improve the mathematical conceptual understanding, students can do to express mathematical ideas to others.

Mathematics is the language of symbols in which everyone who studied mathematics required to have the ability to communicate using language symbols. Mathematical communication skills will make a person can use mathematics for its own sake as well as others, so it will increase positive attitudes towards mathematics both from within themselves and others. Sumarmo [7] suggested that mathematics as a language of symbol simple that mathematics is universal and can be understood by anyone anytime and anywhere. Each symbol has a clear meaning, and agreed to be shared by everyone. For example, the symbol '9', the operation +, - apply nationally each school level wherever that maybe understood by everyone.

Communication ability can support another mathematical abilities, such problem-solving ability. With good communication skills, students can be represented faster properly and this should be supportive for problem-solving. Hulukati[8] states that communication skills is a prerequisite for solving mathematical problems, which means that if students are not able to communicate properly interpret mathematical problems and concepts he can't resolve the problem well. In this regard, Pugalee[9] stated that in order for students to trained mathematical communication skills, the learning of students need to get used to give arguments on each answer and provide feedback on the answers given by others, so that what is learned to be more meaningful for him.

Mathematical communication can be developed in various ways, among them through group discussion. Within Saragih [10] suggests that the ability of communication becomes important when the discussion among the students performed. In the discussion, the students are expected to declare, explain, describe, listen, inquire and cooperate so as to bring the students to a deep understanding of mathematics. Therefore while students communicate their knowledge, they can lead to renegotiation between students' responses, and the role of the teacher is expected only as a filter in the learning process.

Students' mathematical communication is the ability of describing an algorithm and a unique way of solving the problem, the student's ability to construct and explain real-world phenomena serving as a graph, words/sentences, equations, tables and serving physically or ability of the students to give the all edged geometry images.

Mathematical communication are: (a) the central force for students in formulating concepts and strategies; (b) capital for student success and completion of the approach in the exploration and investigation of mathematics; (c) a place for students to communicate with their friends to obtain information, share thoughts and discoveries, brainstorm, assess and refine ideas to convince the others. Broader understanding of mathematical communication proposed by Rombergand Chair(in Sumarmo) [7], namely: (a) connecting real objects, drawings, and diagrams into mathematical ideas; (b) explain the ideas, situations and mathematical relationships orally or in writing with real objects, images, graphs and algebra; (c) declare a daily occurrence in the language or mathematical symbols; (d) listening, discussing, and writing about mathematics; (e) read with understanding a mathematical presentation of written, making conjectures, formulate arguments, formulate definitions and generalizations; (f) explain and make inquiries about the mathematics they have learned.

Baroody[11] suggests five aspects of communication, the five aspects are:

1. Representing, made are presentation means making another form of an idea or a problem, a tabular represented in the form of a diagram or better.
2. Listening, aspect of hearing is one very important aspect in the discussion. The ability to listen to the topics being discussed will affect the student's ability to give an opinion or comment.
3. Reading, the reading process is a complex one, because it related aspect to remember, understand, compare, analyze, and organize what is contained in the passage.
4. Discussion, in the discussions students can disclose and reflect his thoughts related to the material being studied. Students can also ask things that are unknown or still undecided.
5. Writing, writing is an activity performed by the conscious mind to reveal and reflect, as outlined in the media, whether paper, computers and other media.

In this study, mathematical communication skills will be measured through students' ability to express mathematical written communication skills in mathematical problem. In any mathematical problem, measuring communication skills in writing made by the indicators are: the ability to express and illustrate the mathematical ideas in the form of mathematical models that form equations, notation, pictures and graphics, or vice versa.

C. Learning Based on Lesson Study Activities

Students' mathematical thinking ability can be developed through training and habituation carried out repeatedly and continuously. In order to help students have mathematical thinking ability the teacher must be designing a learning process that potentially motivates students to be confident about their ability to solve the problem. Unfortunately the teachers lack of the idea to design learning process when they doing alone. Therefore, teacher can collaborate with another teacher to design learning process. When teachers coming together to design the learning process this activity namely lesson study. Lesson study is a potent embedded peer to peer professional learning strategy. According to Isoda, Stephens, Ohara and Miyakawa [12] lesson study is a process by which teachers of mathematics at several schools in the same community work together to research teaching materials, develop plans (lesson plans) and practice teaching lesson. In lesson study a group of teacher involved collaboratively planning, teaching, observing, and analysis learning and teaching in a research lessons. Lesson study is a scientific activity for teachers who want to develop their student ability, especially in mathematical thinking ability.

Lesson study is recognized with many features one of them is lesson study process or cycle. According to Sato [13] in Indonesia lesson study introduced as an activity consisting of plan-do-see

II. RESEARCH METHOD

This study is a qualitative descriptive study of learning done following the steps in the lesson study activities, This research was conducted in the second semester of the academic year 2013/2014, in Mathematics Program in Faculty of Teacher and Training, University of Muhammadiyah Bengkulu. The subjects were students of fourth semester who took analytic geometry course. Number of students involved is 36. Implementation research is conducted through the stages of the lesson study activities consisting of 4cycles. Each cycle has the following stages.

1. Plan

At this stage, the lecturer models to collaborate with some of the faculty observer to design learning is done by discussing determine the issues to be given to the student. Student centered learning designed with cooperative setting. Learning tool compiled and discussed to be fixed so as to minimize the existing deficiencies. The device is composed of student worksheet, observation sheet for learning activity and mathematical problem solving and communication test

2. Implementation(Do)

Activity at this stage is, lecturers models implement learning activities in accordance with the design that was created earlier. Observations carried out by a team of observers to observe the course of learning.

3. Reflection(See)

At this stage of reflection, lecturers discuss the model and the observer back to discuss the results of the observation of the observer. At this stage the model can be expressed lecturer difficulties encountered when implementing the learning activities. Lecturer observer provide findings that occur during learning activities take place. As the observers may have focused on different parts of the action, this has the advantage that the lesson is seen from several view point by a team who have the idea fresh in their minds.

Data collection in this study was done by

1. Observation

Observations conducted to collect data on learning activities, findings and students' ability in problem solving and mathematical communication. Filling in the form of a narrative observation sheet which can describe the picture of the learning process that occurs.

2. Documentation

Documentation used to obtain activity data plan, do and see through video recordings and written student work on the Student Activity Sheet.

3. Tests

Test scores are used to acquire problem solving skills and mathematical communication students after participating in learning activities.

Furthermore, the data obtained were analyzed qualitatively.

III. RESULT AND DISCUSSION

Result

Results and findings during the course of the lesson study is summarized by the indicators capabilities mathematical problem solving and communication. These indicators can be observed through the activities undertaken by the students during the learning process. Here will be presented the results of observations based on indicators of the problem solving and mathematical communication.

1. Mathematical Problem Solving Ability

Learning activities based on lesson study activities. In the learning activity models begin by reminding prerequisite the material has been learned and convey that learning activities done individually first followed by a discussion in groups and with the final class discussion.

a. Indicators Understanding the Problem

In the first open lesson learning activities begin with teacher give students an open problem related to outbound activities. The purpose of this materials to find the equation circle with a central at the point (a, b).

The problems identified are as follows:

At this stage of understanding the problem arises the opinions of students characterized as proposed by the group A: that the direction of the sun also determines the position of the hood, which means taking into account the displacement towards the north south east west if it is associated with the coordinate plane A rat nor this the direction of the positive y-axis, the south is the negative y-axis, the west is the direction of the negative x-axis and the east as the direction of the positive x-axis. So when there is a shift in the outbound playground will also affect the central of the circle. However, group B has a different opinion, students in this group said that the shift will not shift the playing field flag pole at the central so that the understanding of the game in the beginning of this group to the problem is to add distance to two times the game arena. This shows that students are trying to understand a given problem from the stand point of their own.



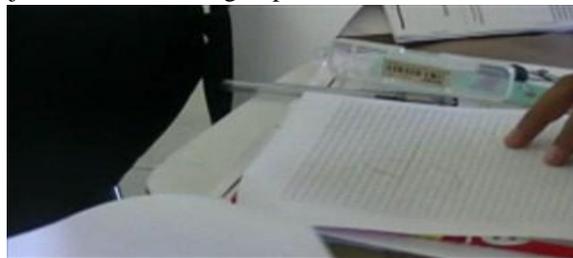
Students actively discuss in a group to understanding the topic

.b. Indicator Planning to Solve the Problem

Based on the understanding of the problem is given each planning group has different settlement. A group planning to shift the center of the circle in the direction of shift in the direction opposite to the direction of the sun so that the selected center is to the east. While group B planned completion by adding a second radius of the circle.

c. Indicators Implementing the Plan

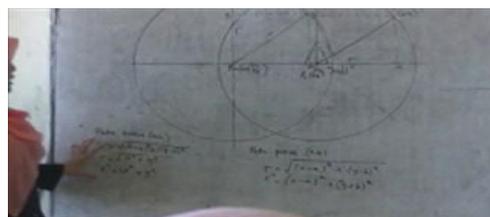
From planning made visible jobs results of each group as shown below:



Students made a plan to solve the problem

d. Indicators Check the Results of Solving Problem

At the time of the class discussion each group presented the results of his work and see if it is right or wrong. Lecturer models provide guidance through questions that dig so that students can summarize the results of solving the problem. The result of solving the problem is a circle equation that has the same radius of the circle in the center of the equation(0.0) but shifted the center of the circle. This shift though towards the right, left or up and down will still produce the same circle equation.



Students discussion their job for check the right answer

2. Mathematical Communication Ability

Mathematical communication skills of students look when they perform well in group discussions and in-class discussion. Almost all students have dared to express his opinion as follows. Student A: That point was originally flag pole, after the sun high and hot atmosphere of the area game on the move with the same distance, the same fingers

Student B: between the first and second position of the same but the distance is summed so that his fingers womanly twelve.

Students already demonstrating that they have the ability to express mathematical idea, interpret and evaluate a problem and can be poured into a mathematical representation that corresponds to his thinking. It is a characteristic of a person who has the ability to reasonable good mathematical communication.

Observations indicate that the student already has the ability to problem-solving and mathematical communication even though there are still some students who have not been up involvement in learning.

Discussion

Students' can solve all of the problems that given by the teacher. This meant the students had high concentration on studying and learning activity more effective, thus the students could understand. In this case, if the students understand the lesson well, they will know the methods of solving the problems, then they will achieve in their study. If students have high activity in learning, their learning achievement will be absolutely higher than having poor activity while studying. Mathematical communication ability was both direct and indirect effect to mathematic problem solving by passing through students presentation. Mathematical communication ability affected the students' mathematic problem solving ability in a positive way.

IV. CONCLUSION

Learning that has been designed by faculty model and the observer was able to bring the train activity and problem-solving ability of students developing mathematical communication pretty well. From the results and discussion in this study it can be concluded that the learning models problems with cooperative setting in lesson study activities in the course of analytic geometry and space field can help the development of problem solving skills and mathematical communication students.

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