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Enhancement Of Mathematical Reasoning Ability At Senior High School By The Application Of Learning With Open Ended Approach

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Abstract

The objective of this research is to investigate the differences of students' enhancement of mathematical reasoning ability as the result of the application of learning with open ended approach and conventional learning. The population in this research was the entire students in high schools and Aliyah in Bandung. The sample is students on grade X. Two classes are randomly selected from each school, one class as an experiment class (open-ended approach) and another class as a control class (conventional learning). The instruments used include mathematical prior knowledge test, mathematical reasoning test, and guidelines for observation. The results of data analysis show that if it is viewed as a whole, students' enhancement of mathematical reasoning who had treated with instruction using open-ended approach was better than students who had treated with regular instruction. There is interaction between learning approach and school levels towards students' enhancement of mathematical reasoning. There is no interaction between learning approach and the initial of mathematical ability towards students' enhancement of mathematical reasoning.
Keywords: Open Ended Approach, Conventional, and Mathematical Reasoning.

Preliminary

Reasoning is defined as the process of thinking as the explanations attempt to show the relationship between two or more based on the properties or certain laws that have been proven true through certain steps and ends with a conclusion (Kusumah, 1986); the process of thinking by thinking groove skeleton particular, the process of thinking with opposite senses of observation or empirical observation, which produces a number of terms and propositions (Suriasumantri, in Alamsyah: 2000). Reasoning mathematically is a habit of the brain work like other habits. Mathematical reasoning offers a way to develop students' horizons about the phenomenon. People who are reasoning and analytical thinking is likely to record the pattern, structure, and regularity in real situations (real-world) and symbolic objects. He will put the question of whether the patterns it coincidence or is there, if it has reason so predictable and verifiable. Finally, mathematical proof is a formal way to express a special reason and justification. In mathematics education, reasoning ability is one of the high-level thinking skills that should be owned by students. Such high level capabilities include: the ability of understanding, communication, reasoning (reasoning), connections, and problem solving mathematically. Curriculum and evaluation standards for school mathematics (NCTM, 1989) has also identified that, communication, reasoning (reasoning), and

problem solving is an important process in learning mathematics in an effort to solve mathematical problems. The ability to reason must be developed consistently using a variety of contexts. Turmudi (2009) states that to develop reasoning skills that students bring to school, teachers should help students argued. Ability to express the argument is important to understand mathematics. Thus, teachers must help students to develop the ability to argue through the disclosure of ideas, exploring phenomena, justifying results, and use conjecture in all branches of mathematics with different expectations, so that mathematic can make sense. The argument may include a strong logical deduction of the conclusion of a hypothetical and should make the students appreciate the value of such arguments.

Reasoning could not be taught only in logic alone, for example by simply spell out the topic of geometry. Mathematical reasoning should be in line with the experience of mathematics students. Examples of simple reasoning is this: if I have the pattern numbers 4, 10, 16, 22, 28, ..., ..., how do I get the next number? Simply students will put forward, I think the next numbers are 34 and 40 because I would always add 6 to the tribe prior to obtain the next number.
The development of mathematical reasoning ability has yet to be achieved at an optimal learning. This is consistent with the results of research Marpaung (Tahmir, 2008) that the current teaching paradigm has characteristics include: (1) teachers' active, passive students, (2) the teacher-centered learning, (3) teachers transfer knowledge to students; (4) student's understanding tends to be instrumental, (5) learning is mechanistic, and (6) students are still (physically) and full concentration (mental) attention to what teachers taught. Furthermore, also stated that the results are based on the paradigm of teaching and learning, among others are: (1) students are not pleased with the math, (2) students' understanding of mathematics is low; (3) ability to solve problems (problem solving), reasoning (reasoning), communicate mathematically (communication), and saw the connection between concepts and rules (connection) is low. By looking at these facts, to enhance the ability of mathematical reasoning, then the learning needs to be repaired, one through innovation in designing learning approach.
MONE (2006) states that, so that students have the ability to think mathematically the learning of mathematics must begin with a dish of issues appropriate to the situation (contextual problems). Research Suryadi (2005) on the development of high-level

mathematical thinking through the indirect approach, there are two fundamental things that need further assessment as well as research and depth of student-material relationship and teacher-student relationship. In that study found that in order to encourage a mental action, the learning process must be preceded by a dish that contains the problem challenges students to think. Besides the learning process, should also facilitate the students to construct knowledge independently or concepts so that students will be able to rediscover the knowledge (reinvention). One approach to learning that can enhance students' mathematical reasoning ability is an open-ended approach to learning. The purpose of the Open-Ended learning problems according to Nohda (Suherman, et al, 2003; 124) is to help develop creative activities and students' mathematical thinking through problem posing simultaneously. Ability to think creatively and mindset will lead students in mathematical reasoning ability. Open-Ended approach gives students the chance to investigate various strategies and ways that he believes in accordance with the ability to elaborate on the issue. The aim is that mathematical thinking skills of students can develop optimally and at the same time the creative activities of each student communicated through the learning process. This is the main idea of learning with the Open-Ended, namely learning to build interactive activities between mathematics and students, so invite the students to answer the problem through various strategies. Examples of application of the Open-Ended problems in learning activities when students are asked to develop the method, manner or a different approach in responding to a given problem is not oriented to answer (result) end.

The trend of learning mathematics at this time, did not facilitate students to conduct an investigation and exploration of knowledge freely. The teacher explains the subject matter is still active, giving examples and exercises while the students act like machines, the students listen, take notes and do the exercises the teacher. In the process of learning, mathematics is presented in the form of basic concepts, explanation of concepts through examples, and problem solving exercises. The learning process is generally performed in line with the pattern of the dish as it is available in reference books. The learning process is more likely to encourage such thinking processes as a result of the reproductive process of reasoning that was developed more imitative. Situations like this provide less room for improving high-level thinking skills and critical and creative thinking for students, because students tend to solve math problems

by looking at examples that already exist, so that when given non-routine problems, students' difficulties. In these conditions, students are not given much time to find their own knowledge because learning is more teacher-dominated. Class or group discussions are often not implemented, so the interaction and communication between students with other students and students with the teacher does not appear. As for the formulation of research problems are as follows:

1. How the extent to which an increase in mathematical reasoning ability of students learning math with a model of open-ended approach?
2. Are there differences in students' increased ability to reason according to the interaction between students learning math with a model of open-ended approach with students who are learning math with the conventional model of learning approaches in terms of levels of mathematical ability in general?
3. Is there a difference in increasing student reasoning in performing mathematical communication according to the interaction between students who are learning math with a model of open-ended approach with students who are learning math with the conventional model of learning approaches in terms of type of school?

Based on the formulation of the above problems, the objectives are as follows:

1. Analyze comprehensively improvement of mathematical reasoning abilities of students learning mathematics to model the open-ended approach.
2. Analyzing differences in the increase students' ability to perform mathematical reasoning according to the interaction between students learning math with a model of open-ended approach with students who are learning math with the conventional model of learning approaches in terms of levels of mathematical ability in general.
3. Analyzing differences in the increase students' ability to perform mathematical reasoning according to the interaction between students learning math with a model of open-ended approach with students who are learning math with the conventional model of learning approaches in terms of types of schools.

Theory Study

1. Mathematical Reasoning Ability

Reasoning is defined as the process of thinking as an attempt an explanation in an attempt to show the relationship between two or more based on the properties, or certain laws that have been proven true through certain steps and ends with a conclusion (Kusumah, 1986); the process of thinking according to the groove framework of certain

thinking, thinking processes with opposite senses of observation or empirical observation, which produces a number of terms and propositions (Suriasumantri, in Alamsyah: 2000).

The term reasoning is a translation of reasoning which is defined as the process of reaching a logical conclusion based on facts and the relevant sources (Shurter and Pierce, in Dahlan 2004: 21); how to transform the information given in a specific in order to reach conclusions (Galloti, in Matlin: 1994) ; the process of thinking done in a way to deduce a general conclusion and can be drawn from the cases are individual, but can also reverse, from things that are common to the individual ones (Suherman and Winataputra, 1983: 222).

Broadly speaking, the reasoning is divided into two, namely inductive and deductive reasoning. Inductive reasoning is a reasoning process that lowers the general principles or rules of observation matters or case examples. Whereas deductive reasoning is a reasoning process of knowledge or experience that the general principle that leads us to obtain conclusions for something special.

According Sastrosudirjo (Alam, 2000: 10) reasoning abilities include: (1) public reasoning associated with the ability to find a solution or a problem solver, (2) deduction capabilities: the ability-related abilities, such as in syllogism, and relate to the ability assess the implications of an argument, and (3) the ability to see relationships, not only the relationship between objects but also the relationship between ideas, and then use that relationship to obtain objects or other ideas.

NCTM (1989: 134) states that at the 5-8 grade students, the math curriculum should include a lot of diverse experience that can reinforce and extend logical reasoning skills so that students can (1) know damn apply deductive and inductive reasoning; (2) understand and apply reasoning processes with special attention to the reasoning with proportions and graphs, (3) make and evaluate conjectures-kunjektur and arguments logically; (4) assess the absorptive capacity and power of reasoning as part of mathematics.

The indicators of students' abilities that can be developed in mathematical reasoning or reasoning in mathematics according to Utari (2006) are: (1) draw logical conclusions, provide an explanation by using models, facts, traits, and relationships, (2) estimate answers and solution processes, and use patterns and relationships to analyze

mathematical situations, draw analogies and generalizations, (3) develop and test the conjecture, giving opponents an example, (4) follow the rules of inference. Constructing valid arguments, examine the validity of the argument, (5) arrange a direct proof, indirect proof, and mathematical induction. From the description above, indicators of mathematical reasoning abilities that are used in this study is to provide an explanation of the models, pictures, facts, traits, relationships, or patterns that exist, follow logical arguments and draw logical conclusions.

2. Open Ended Learning Model

a. Understanding the Open-Ended Approach

According Suherman et al (2003; 123) problem is formulated has the correct much answers called the problem of incomplete or also called the Open-Ended problem or question open. Students who are faced with the Open-Ended problem, its main purpose is not to get an answer but more emphasis on how to arrive at an answer. It is not only one approach or method of getting answers, but few or much.

The nature of "openness" of a problem said to be lost if there is only one way to answer a given problem or there is only one possible answer to the problem. Examples of application of the Open-Ended problems in learning activities when students are asked to develop the method, manner or a different approach in responding to a given problem is not oriented to answer (result) end.
Learning with the Open-Ended approach begins by providing an open problem to students. Learning activities should lead and bring the students in answering the problem in many ways and allows also has a lot of answers (correct), thus stimulating students' intellectual abilities and experience in the process of discovering new something.

The purpose of the Open-Ended learning problems according to Nohda (Suherman, et al, 2003; 124) is to help develop creative activities and students' mathematical thinking through problem posing simultaneously. In other words, creative activities and students' mathematical thinking should be developed as fully as possible in accordance with the abilities of each student.
Open-Ended approach gives students the chance to investigate various strategies and ways that he believes in accordance with the ability to elaborate on the issue. The aim is

that mathematical thinking skills students can develop optimally and at the same time the creative activities of each student communicated through the learning process. This is the main idea of learning with the Open-Ended, namely learning to build interactive activities between mathematics and students, so invites the students to answer the problem through various strategies.

In learning with the Open-Ended approach, students are expected not only to get an answer but more emphasis on the process of finding an answer. According Suherman et al (2003:124) argues that in mathematical activities and student activities are called open if it satisfies the following three aspects:

1) Student activities should be open, ie the learning activities to accommodate students the opportunity of student to do things freely according to their whish.
2) Mathematical activity is a variety of thinking, thus learning activities should emphasize the process of abstraction from real experience in everyday life into the world of mathematics, or vice versa.
3) Student activities and the activities of mathematics is one unit. In learning mathematics, teachers are expected to raise the understanding in mathematics thinking in accordance with individual abilities. Although in general, teachers will prepare and implement appropriate learning experiences and considerations of each. Teachers can be students to learn through activities that systematically higher mathematics or mathematics through activities that are fundamental to serve students who's low ability. Uniteral approach of this kind can be said to be open for the needs of students and open for the ideas of mathematics.

Basically, the Open-Ended approach aims to raise students' creative activities and mathematical thinking simultaneously. Hence, thing has to think is the freedom of students to make a progress of solving thinking in accordance with the skills, attitudes, and interests that will ultimately form the students' mathematical intelligence.

b. Constructing the Open-Ended Problems

According Suherman, et al (2003:129-130) the construction and development the right and good Open-Ended problem for students with varying levels of ability are not easy. However, according to a study conducted in Japan in the time period is long

enough, found some things that can be used as reference in constructing the problem, among others, as follows:

1) Presenting the problem through a real physical situation in which mathematical concepts can be observed and assessed by student.
2) Presenting problems of proof can be modified in such a way that students can discover relationships and properties of the variables in the problem.
3) Presenting forms or wake-up (geometry) so that students can make a conjecture.
4) Presenting the sequence of numbers or tables so that students can find the rules of mathematics.
5) Giving some concrete examples in several categories so that students can elaborate on the properties of the sample to discover the properties of the sample so to find common traits.
6) Giving some similar exercises so that students can generalize their work.

c. Planning of Open-Ended Approach

If the teacher has to construct issue Open-Ended well, three things must be considered in the study before the problem was shown in class those are:

1) Is the problem that rich with mathematical concepts and valuable? Open-Ended Problems should be encouraging students to think from different perspectives. It also should be rich with mathematical concepts which appropriate for students capable of high or low by using different strategies according to their abilities.
2) Does the math of the matter is appropriate for students?
   By the time students complete the problem of the Open-Ended, they must use the knowledge and skills they have got. If the teacher predicts that the problem was beyond the reach of student ability, then the matter shall be modified / replaced with a problem that originated in the area of students' thinking.
3) Is the problem that invites further development of mathematical concepts? The problem must have a connection or relationship with the concepts of higher mathematics that can spur students to higher-order thinking.

The stages that must be considered in developing learning plans are as follows:

1) Write the student responses are expected.

Learning mathematics with the Open-Ended approach, students are expected to respond the problems in various ways point of view. Therefore, teachers must prepare or write a list of anticipated student responses for the problem. Limited in the ability of students to express ideas or thoughts, maybe students will not be able to explain its activity in solving the problem. But students may also be able to explain mathematical ideas in different ways. Thus, anticipation of teachers to create or write response raised the possibility of students to be critical in directing efforts and help students solve problems in accordance with the way of his ability.

2) The purpose of the problem given to students must be clear.

   The teacher understands well the role that problem in the overall learning plan. Problems can be treated as a specific topic, such as the introduction of new concepts to student's, or as a summary of the activities of students learn some vital lessons. Based on experience, the problem of the Open-Ended effectives for the introduction of a new concept or a summary of learning activities.

3) Serve as attractive as possible problems for students.

   Context of a given issue or presented should be known well by students, and should arouse students' curiosity and intellectual passion. Therefore the issue of Open-Ended needs time to think and consider the solution strategy, then the matter shall be able to attract students' attention.

4) Complete the principles of problem formulation, so that students easily understand the intent issue.

   Problems must be expressed in such a way that students can understand it easily and find the solution approach. Students may have trouble if the problem is too short explanation. It may arise because the teacher intends to give sufficient inroads to the students to choose how and problem-solving approach. Or can be caused by students having little or no experience to learn because accustomed to follow clues from the text book.

5) Give enough time for students to explore the issue.

   Sometimes it is not enough time allotted in the present problem, solve it, discuss the approach and completion, and summarizes what has been learned from the students. Therefore, teachers must give sufficient time for students to explore the

issue. Actively discuss among fellow students and between students and teacher this interaction is very important in learning with the Open-Ended approach.

d. Open-Ended Approach Advantages

Open-Ended Approach according Suherman, et al (2003:132) has several advantages, among others:

1) Students participate more actively in the learning and often express his ideas.
2) Students have more opportunities in the use of mathematical knowledge and skills in a comprehensive manner.
3) Students with low math ability to respond to problems in their own way.
4) Students are intrinsically motivated to give evidence or explanation.
5) The students have many experiences to find something in answering the problem.

e. Weaknesses Open-Ended Approach

Besides the advantages, according to Suherman, et al (2003: 133) there are also weaknesses of the Open-Ended approach, including:

1) Create and prepare a meaningful mathematical problems for students is not an easy job.
2) To raise directly an issue that students understood are very difficult so that many students who have difficulty how to respond for a given problem.
3) Students with high ability may feel hesitant or worried about their answers.
4) There may be in part of students who feel that their learning activities are not fun because of the difficulties they face.

Research Hypothesis

In accordance with the formulation of the problem and study the theory that showed above, the authors formulate the hypothesis as follows:

1. There is a difference in increasing students' reasoning skills between students who get open ended learning model with conventional one.
2. There is interaction between the model of open ended learning and conventional one with the category schools in mathematical reasoning skills.

3. There is interaction between the learning approach (open ended and conventional) with prior knowledge of mathematics (PAM), namely the upper, middle and bottom in mathematical reasoning skills.

Research Methods

This type of research is a quasi-experimental and preceded by the development of learning tools and instruments of research with the research design is the design of the control group pre test-post test with the form:

A O X O

A O O

A = sampling random class.

O = pretest and post test in the experimental group and control group.

X = model approach to open ended learning.

Research Results

1. Mathematical Communications Upgrades

The subject of this study was followed by 140 students consisting of 70 Senior High school students and 70 students of Islamic Senior High School (Madrasah Aliyah). Grouping students based on test results prior knowledge of mathematics (PAM) students. The numbers of students who are at the top, middle, and lower in Senior High School and Islamic Senior High School categories are presented inTable 1.

Table 1. PAM Group School Students by Category Group

Grouf of students	Category of School		Total
	SMU	Aliyah	
Top	14	12	26
Middle	36	34	70
Botton	20	24	44
Total	70	70	140

To determine the extent of increase in capability of reasoning mathematical models of students learning math with open ende learning models, used test gain normalized according to Melzer (2002) with the formula:

Normalized gain (g) = (Score Post test-pretest score) / (Score Ideal-pretest score)

Category normalized gain (g) is: g <0.3 is low; $0.3 \leq g$ <0.7 is moderate, and $0.7 \leq g$ is high. Based on the analysis of research data, with the ideal score 80 obtained the data presented in Table 2 below,

Table 2. Mathematical reasoning Upgrades

Number of Subjects	Post test Average	Averaged Pretest	Gain normalized	Criteria
70	63.18929	44.95	0.520366	Moderate

In Table 2, the obtained mean normalized gain (g) = 0.520366 with the criteria middle. This means an increase in students' mathematical reasoning abilities that open-ended learning, including middle average.

2. Comparison of Mathematical Reasoning Ability

Testing Hypothesis 1: Hypothesis 1 was tested with a one lane, hypothesis tested is H_0: There is no difference in students' mathematical reasoning skills between students who get open ended learning model with conventional. Summary of results of Analysis variant test a path is presented in Table 3 below,

Table 3. Recapitulation of Mathematical Reasoning Ability Test Differences

Approach	Sum of Squares	Df	Mean Sum of Squares (RJK)	$F_{Counting}$	F_{Table}	Sig.
Interagency Group	785.5367	1	54202.03	4.097082	3.91	$\alpha = 0.05$
Inter Group	13229.42	136	191.7308			

From table F distribution with degrees of freedom 1 and 136 with stage means $\alpha = 0.05$ obtained F_{table} value = 3.91. Given $F_{Counting}$ = 4.097082 is greater than F_{Table} = 3.91, then the hypothesis that told the difference does not exist, denied. Thus, there is a difference between students' mathematical reasoning skills that get with the open ended model and one.

Testing Hypothesis 2:

Hypothesis 2 was tested with analysis variant two lanes, hypothesis tested is H_0: There is no interaction between the model of open ended learning and conventional with

categories of schools in mathematical reasoning skills. Summary of results of analysis variant test with two pathways are presented in Table 4 below,

Table 4. Mathematical Reasoning Capability Differences
Based Approach and Category of School

Source of	Sum of Squares	Df	Mean Square	$F_{Counting}$	F_{Table}	H_0
School category	73.95045	1	73.95045	0.571998	3.91	Accepted
Approach	6606.879	1	6606.879	51.10346	3.91	Rejected
Interaction	16215.78	1	16215.78	125.4272	3.91	Rejected
Total	17324.11	136	129.2844			

From the results of analysis variant test with two lines in Table 4, the values obtained $F_{Counting}$ = 125.4272 with F_{Table} value = 3.91 with $\alpha = 0.05$, then the null hypothesis (H0) is rejected. This means that there is interaction between the learning approach and category of schools on students' mathematical reasoning ability.

Testing Hypothesis 3:

To test Hypothesis 3 used two-lane analysis valiant test. The hypothesis tested is H_0: There is no interaction between learning approaches (Open ended and Conventional) with prior knowledge of mathematics (PAM), namely: the upper, middle and bottom in mathematical reasoning skills. Summary of results of analysis variant test two pathways are presented in Table 5 below,

Table 5. Mathematical Reasoning Ability Differences
Based Approach and PAM

Source of	Sum of Squares	df	Mean Square	$F_{Counting}$	F_{Table}	H_0
Approach	14329.07	1	14329.07	16.63002	3.92	Rejected
PAM	4.588776	1	4.588776	0.005326	3.92	Accepted
Interaction	342.3482	1	342.3482	0.397322	3.92	Accepted
Total	4308.193	5	861.6385			

From the Analysis variant test results in Table 5, the values obtained $F_{Counting}$ = 0.397322 less than the value F_{Table} = 2.44 with $\alpha = 0.05$, the null hypothesis (H_0) is received. This means there is no interaction between learning approach and PAM on the ability of students' mathematical reasoning.

Discussion

The results showed that the average normalized gain (g) is 0.520366 which is at criteria was significant improvement of mathematical reasoning abilities of students with learning open ended, including being average, but overall have not reached the thoroughness because the average learning outcomes are only 63,18929 below of the limit value of the thoroughness of 65,00.

The results of comparison of mathematical reasoning ability among students who received mathematics learning with open-ended approach is significantly better than students who received conventional learning approaches. As for the type of school (Senior High School and Islamic Senior High School) and knowledge of early mathematics learning approach used did not show significant differences.

These results illustrate that the open ended approach to learning more influence on mathematical reasoning ability increased as compared with conventional learning approaches. This is due to open-ended approach to learning more emphasis on understanding the material significantly by approaching students on math problems that are close to students' lives and prior knowledge of students, so students have the opportunity to evaluate a situation or problem by identifying the needed elements, investigation, exploration, problem solving, and reflection. Students participating more actively in the learning and often express his ideas. Students have more opportunities in the use of mathematical knowledge and skills in a comprehensive manner. Students with low math ability to respond the problems in theirs own way. Students are intrinsically motivated to give evidence or explanation. In addition, students have to find something a lot of experience in responding the problems. The teacher's role is as facilitator and provide assistance if needed. While the conventional approach to learning more emphasis on math problems on a regular basis so that students finish it in algorithmic.

Conclusion

Based on the analysis, findings, and discussions noted above, the obtained results the following conclusions:

a. Average normalized gain is at the criteria being. This means an increase in students' mathematical reasoning abilities that open-ended learning, including middle average.
b. There is a difference in increasing students' mathematical reasoning ability among students who have learning model and conventional open ended.
c. There is interaction between the learning model Conventional open ended and the categories of school in mathematical reasoning ability.
d. There is no interaction between learning approaches (Open ended and Conventional) with prior knowledge of mathematics (PAM), namely: the upper, middle and bottom in mathematical reasoning ability.

Suggestion

Based on the conclusion above, the author proposes some suggestions for further research and related parties as follows:

a. Open ended learning approach should be developed and used as an alternative choice for teachers in learning mathematics.
b. The results showed that with the application of open-ended approach to learning students' learning outcomes with have not reached completeness. Thus, to improve the learning outcomes so in implementing the open-ended approach to learning need to consider students 'prior knowledge of mathematics and teaching materials based contextual problem it hoped there is challenging students' thinking and lead to students 'cognitive conflict, so as to develop every aspect of students' mathematical reasoning ability optimally.
c. By considering the finding that open-ended approach to learning, it can improve students' mathematical reasoning ability, it is expected that its application to material inputs for policy makers and can disseminate in a wider area.

List Theory

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