THE IMPACT OF PROBLEM-BASED LEARNING APPROACH TOSENIOR HIGH SCHOOL STUDENTS' MATHEMATICS CRITICAL THINKING ABILITY

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Abstract

The study was report the findings of an only post-test control group research design and aims to analyze the influence of problem-based learning approach, school level, and students' prior mathematical ability to student's mathematics critical thinking ability. The research subjects were 140 grade ten senior high school students coming from excellent and moderate school level. The research instruments a set of mathematical critical thinking ability test, and the data were analyzed by using two ways ANOVA and t-test. The research found that the problem-based learning approach has significant impact to the ability of students' mathematics critical thinking in terms of school level and students' prior mathematical abilities. Furthermore. This research also found that there is no interaction between learning approach and school level, and learning approach and students' prior mathematics ability to students' mathematics critical thinking ability.

Keywords: problem-based learning, mathematical critical thinking ability

Abstrak

Makalah ini melaporkan temuan suatu penelitian berdesain hanya tes akhir kelompok kontrol dan bertujuan menganalisis pengaruh pendekatan berbasis masalah, level sekolah, dan kemampuan awal matematis siswa terhadap pencapaian kemampuan berpikir kritis matematis siswa. Subjek penelitian ini sebanyak 140 siswa kelas X SMA yang berasal dari level sekolah tinggi dan sedang. Instrumen penelitian ini adalah seperangkat tes kemampuan berpikir kritis matematis, dan data dianalisis dengan menggunakan ANAVA dua jalur dan uji-t. Studi menemukan bahwa pendekatan pembelajaran berbasis masalah memberikan pengaruh yang signifikan terhadap kemampuan berpikir kritis matematis ditinjau dari peran level sekolah dan kemampuan awal matematis siswa. Studi menemukan pula tidak terdapat interaksi antara pendekatan pembelajaran dan level sekolah, dan antara pendekatan pembelajaran dan kemampuan awal matematis terhadap kemampuan berpikir kritis matematis siswa.

Kata Kunci: pembelajaran berbasis masalah, berpikir kritis matematis

Nowadays, mathematics critical thinking ability is an important mathematics basic competence in math education unit level curriculum (SBC) which exist in the Republic of Indonesia. The importance of the ability not only to meet the demands of learn mathematics but also to the student awareness of the importance of mathematics in other subjects and human life. Ruseffendi (2008) stated that the use of mathematics taught in school, is math as a provision in everyday life and mathematics in order to educate the nation. Thus, the characteristics possessed mathematics can bring math learning leads to build students' thinking skills.

Basically every student has the ability to think critically on mathematics, but the problem is how we bring critical thinking skills and mathematical development and increases mathematics critical thinking skills through learning mathematics. According to Krulik and Rudnick (NCTM, 1999) mathematics critical thinking is thought that tested, questioned, connect, and evaluate all aspects that exist in a situation or a problem. Meanwhile, in the process of mathematics critical thinking, students will make a statement relating to the problems encountered, then connect the existing problems with the knowledge and experience that has been chosen.

Ennis in Baron and Stenberg (1987) stated that critical thinking is defined as reflective thinking which is grounded and focused on the determination of what is believed or done. Furthermore, it's said by Ennis (Sabandar, 2007), the real critical thinking is a process that occurs in a person's thinking and aims to make decisions that make sense about something he can believe as the truth and that will be done later.

According to Glazer (2001), critical thinking in mathematics is the ability that involves prior knowledge, mathematical reasoning, and cognitive strategies to generalize, prove, or evaluate the lesser-known mathematical situations effectively. Teachers in mathematics learning should facilitate students in developing the critical thinking process, it means that teachers must take action which reflects the capabilities recommended by the Glazers.

Another researcher, Ennis (Innabi, 2003) stated that aspects relating to the subject matter includes: generalizing concepts, skills and algorithms, as well as problem solving, with indicators of each aspect of thinking with regard to the subject matter includes: (1) aspects related to the concept which include identify the characteristics of the concept, and comparing the concept to another; (2) aspects relating to the generalization which include define the concept contained in the generalization and association, and determine the conditions applying generalizations; (3) aspects relating to the skills and algorithms which include classify conceptual basis of skill, and comparing students' performance with exemplary students' performance; and (4) aspects relating to problem solving such as providing a common form for the purpose of settlement, and specify the provided information.

Above descriptions leads to the conclusion thatmathematics critical thinking is a systematic ability to incorporate prior knowledge, mathematical reasoning abilities and also be able to apply cognitive strategies in mathematical problem solving. Thus the mathematics critical thinking encompass the skills to analyze and examine the validity of an argument, identify problems based on a graph or diagram, identifies the adequacy ofthe data of the problem, can select or sort out in the best way of solving problem and evaluate the resolution process.

Indicators of mathematics critical thinking skills that used in this study include: (1) find a relationship, that is the students's ability to reconstruct the elements of the problem and formulate a relationship in the solution;(2) analyzing the data, that is the ability of students to identify and take decisions on encountered problem;(3) analyzing the elements, that is the ability of students to identify the elements contained in a relationship;(4) analyzing the relationship, that is the ability of students to

check relationship and interactions between the elements of the problem and then make a decision as to its completion;(5) criticizing the evidence, that is the ability of students to make comments, peel, add, subtract, or rearrange a mathematical proof that they have learned;(6) solving the problem, that is the ability of the students in the examination results or answers in solving problems.

Mathematics learning that can build and developstudent's mathematical critical thinking skills is the learning that designed to activate students with a non-routine problems to be solved by the students either individually or in groups. This is in line with the curriculum 2006, which is in the process of learning, the child is considered as a resource of knowledge, the position of teachers in this curriculum are no longer dominating the class but as a facilitator.

Mathematics learning problems in school ist still dominated by the factor of teachers and students. Some researchers describes the mathematics learning outcomes in schools have not shown satisfactory results (Djajuli, 1999; Sumarmo, 1999). The survey results IMSTEP-JICA (1999) in Bandung found that one of the causes of poor quality of studentsmathematical understanding is due to the learning process of mathematics. Teachers are generally too concentrated on problem solving exercises that are generally more than the procedural and mechanistic rather than mathematical understanding, students tend to be passive because in learning activities the teacher as the only source of information that usually explains the concept informatively through sample questions and exercises.

Results of mathematical learning by using the conventional approach that usually centered on the teacher and by using expository method causes passive students, less excavated of students' high order mathematical thinking skills, such as logical thinking, critical thinking, creative thinking and other capabilities (Herman, 2007; Ratnaningsih, 2007; Suryadi, 2005; Mulyana, 2008; Ismaimuza 2010; Mahmudi, 2010).

Learning that exposes problems in mastering the concept is a problem-based learning (PBL). The teacher's role in the PBL is a designer, organizer and facilitator of learning. PBL is a learning approach that begins with exposes students to the math problem, then students are required to solve the problem that is rich with mathematical concepts. One of the characteristics of PBL is positioned students as self-directed problem solver through collaborative activities to encourage students to be able to find the problem and plan completion, trains students and familiarize skilled serves to reflect the findings in the inquiry about the effectiveness of their way of thinking in solving the problems that faced.

Problem-based learning is an approach to learning that challenges students to learn through problem solving which done by cooperatively in small groups. According to Tan (Rusman, 2012) in the PBL students' thinking skills are really optimized through a process of group or team work systematically, so students can empower and float their capacity to think on an ongoing basis. Thus in the PBL teachers and students are required to be able to display issues aimed at achieving mastery of concepts covered through thinking skills and creativity achievement of learning resources.

Ibrahim and Nur (2000) recommended that the PBL is a learning approach that is used to stimulate student's high-order thinking in a situation that is oriented to real-world problems, including thinking how to learn. Furthermore, Moffit (Depdiknas, 2002) proposes that PBL is a learning approach that uses real-world problems as a context for students to learn about critical thinking and problem solving skills.

Torp and Sage (1998) stated that math and science can achieve success by applying PBL. Moreover, according to Herman (2006) through PBL, students are conditioned to be able to think flexible, filed conjecture, solve problems and find common rules. So that in its application, PBL requires the readiness of teachers and students to be able to collaborate in resolving the raised issues. Teachers must be prepared to be a supervisor at the same tutor for students who can provide motivation, encouragement and help in mastering the skills of problem solving.

Objectivity of PBL according to Resnick (1987) are thinking and problem solving skills, and modeling of adults who provide rationality about how the PBL help students to perform in real life situations and learn the importance of the role of adults. Additionaly, Ibrahim and Nur (2002) argued in detail of PBL goal that is to help students develop the thinking skills and problem solving skills, learn various adult roles through their involvement in a real experience, and become autonomous students. Hence, PBL can be used depending on the objectives to be achieved, whether related to: (1) acquisition of content knowledge that is multidisciplinary;(2) the acquisition of skills and heuristics discipline process;(3) learning problem solving skills;(4) learning wider life skills. As a result, the broader PBL purpose the more complex of problems becomes, and also the more important PBL steps or cycles processes require.

In this research, PBL steps that is used are: (1) study carried out for 2 hours of lessons;(2) in the first 5 minutes the teacher explains about lesson that will be applied following the tasks that must be done by students and procedures for assessment, then create groups of students;(3) each group was given problem and for 40 minutes discussing in groups;(4) during the 10 minutesis class discussion and the issues that arise in the discussion group, discussed together in the classroom and students integrate new knowledge into the context of the problem;(5) for 30 minutes to do a presentation of each group is accompanied by a question and answer;(6) for 5 minutes the teacher gives a summary of the material at the meeting that day and deliver the tasks groups and individuals.

METHOD

Research Design

This study is a quasi-experimental research by applying problem-based learning approach in learning mathematics. Research units is determined based on the grade level of the school, group learning and students' prior mathematical school ability level is set according to the classification of the local Ministry of Education (based on the ranking of national exam results) chosen two schools:

one school with a high level and the other one is moderate. From each school selected two classes, one class for a class experiment, and another class as the control class.

The sample in this research were not randomly selected but classes by using existing classes and selected whose schedule does not intersect because researchers act as a teacher. The experimental class were treated PBL (X), and the class is given control of conventional learning (CL). After the study is completed the final test is held (O), which tests the ability of mathematics critical thinking. Afterward, the research involved two groups at each school level, so that the design uses a static group (Ruseffendi, 2005).

Research Subject

Population of subjects in this research was all students in high school (SMA) from two schools in the Kotamadya Bandung with different levels in which excellent and moderate level. Then, selection of high school students as subjects based on the consideration that the population of high school students already have a diversity of academic ability and level of thinking is estimated to be superior compared to elementary and junior high school students, so that the implementation of the PBL can run as expected. Kotamadya Bandung was chosen because based on the consideration that the characteristics of high school students relatively the same as high school students in other major cities, especially in West Java.

From each school were selected two sample classes, namely the experimental class and control class. Then, selection of these classes is not done randomly, but selected classes that have the same or adjacent the schedule is not as in this research, the researchers acted as a teacher. Then, at the excellent school level the number of students in each class of 35 people, and at the moderate school level is selected bythe number of active students in each class of 35 people. Subject that selected are grade ten.

Data Analysis

In this research, aquantitative data were analyzed by using ANOVA with two lines and t-test. The effect of problem-based learning approach to the critical thinking skills of students by school level mathematical and early mathematical ability was determined.

RESULT AND DISCUSSION

In this section, conventional learning (CL) and problem-based learning of mathematics will be described clearly. The purpose of this study was to analyze and comprehensively reveal the quality of critical thinking skills among students' whos obtain mathematical problem-based learning (PBL) and conventional learning (CL). In addition it also analyzed the interaction between the school and the level of learning with prior mathematical ability as well as describe the implementation of problem-based learning at each school level.

In this study, the data included quantitative data in the form of prior mathematical ability test (PMA) and mathematics critical thinking ability tests, to 140 students consisting of 70 students PBL, and CL 70 students coming from high school level and being Data from tests showed minimal completeness criteria (MCC) mathematics critical thinking skills was 32. 5 (65% of the ideal score).

Mathematic critical thinking skills data test results described and analyzed based onfactors: group learning model, the level of school and the students' prior mathematical ability (PMA). In this study, a minimum completeness criteria (MCC) of mathematics critical thinking skills are 32. 5 (65% of the ideal score). The data processing an average score of students' critical thinking skills and PBL 37. 7 percentage MCC achievement by 80%, the average score of 32. 57 and less CL MCC percentage achieved by 50% has been obtained.

A comparative analysis of critical thinking skills among students that acquire PBL and CL, is started with the distribution normality test by using the test *KolmogorofSmirnov*Z (KS Z) and the data score of mathematics critical thinking skills for each learning model was normal distributed. Moreover, homogeneity test of population variance of scores of mathematics critical thinking skills based group learning by using *Levene* test, and the population variance of scores of mathematics critical thinking skills based learning model of homogeneous has been obtained.

Both sets of data were normally distributed and homogeneous variance, so proceed with calculating the average difference in the two groups of data based model of learning by using t-test. The calculations shows that in the group of data of all students there are significant differences of students' mathematics critical thinking skills between the students who acquire PBL and CL with an average PBL students greater than CL students.

An analysis of the interaction between learning approaches and school level to the ability of mathematics critical thinking, starting with the normal distribution test and homogeneity of variance test. The calculations shows that the mathematics critical thinking skills score dataon normal distribution *(Kolmogorov-Smirnov* test). Then, population variance of scores of mathematics critical thinking skills based on group learning approaches and school level is homogeneous (using test *levene).*

Due to the normal distribution of data groups and homogeneous variance, so to determine the presence or absence of interaction between learning approaches and school level in critical thinking skills used mathematical two ways ANOVA. Summary results of two ways ANOVA are presented in Table 2.

Table 2. The interaction between the test and Level Schools Learning Approach to Students' Mathematics Critical Thinking Ability

Source	Sum of Squares	Dk	The average squared	F	Sig.	H_0
Learning	920. 579	1	920. 579	48. 129	0,000	**Rejected**
Level Schools	1004. 464	1	1004. 464	52. 515	0,000	**Rejected**
Interaction	146. 064	1	146. 064	7. 636	0. 007	**Rejected**
Total	177,505. 000	140				

Referring in Table 2, it can be concluded that the learning approach has significant impact to the students' mathematics critical thinking ability. This is indicated by the value of probability *(Sig.* = 0. 000) smaller than 0. 05. Similarly, at the school level also have a significant influence on the ability of mathematics critical thinking. ANOVA test results shows the value of F = 0. 636 with probability value *(Sig.)* = 0. 007 (less than 0. 05), then there is no interaction between learning approaches and school level to the students' mathematics critical thinking ability.

An analysis of the interaction of learning approaches and prior mathematical ability on the ability of mathematics critical thinking, starting with the normal distribution test and homogeneity of variance test. The calculations show that the mathematics critical thinking skills score on normal distribution data *(Kolmogorov-Smirnov* test). Population variance of scores of mathematics critical thinking skills based group learning approach and prior mathematical ability is not homogeneous (level test).

Furthermore, to determine the presence or absence of interaction between learning approach and prior mathematical ability (PMA) to the critical thinking skills used mathematical ANOVA two lanes. Summary results of two ways ANOVA are presented in Table 3.

Table 3. The interaction between the Learning Approach and PMA to Students' Mathematics Critical Thinking Ability

Source	Number Quadratic	Dk	Average Quadratic	F	Sig.	Ho
Learning	771. 451	1	771. 451	50. 056	0,000	Rejected
Ex. PMA	1643. 890	2	821. 945	53. 332	0,000	Rejected
Interaction	31,990	2	15. 995	1,038	0. 357	Be accepted
Total	177,505. 000	140				

Following in Table 3, it can be concluded that the learning approach has significant impact on the students' mathematics critical thinking ability. This is indicated by the value of probability *(Sig.* = 0. 000) smaller than 0. 05. Similarly, at the early mathematical ability (PMA) also have a significant influence on the students' mathematicscritical thinking ability. ANOVA test results in Table 3, the value of F = 0. 730 with probability value *(Sig.)* = 0. 484. (Greater than 0. 05), then there is no interaction between learning approach and prior mathematical ability.

CONCLUSIONS AND RECOMMENDATION

From the data analysis and discussion of the results obtained by the conclusion of this research are students who follow the problem-based learning approach has better mathematics critical thinking ability than student who take conventional learning. There is interaction between the learning approach factor and school-level factor on the student's mathematics critical thinkingability. There is no interaction between the learning approach factor and students' prior mathematics ability factor. Based on the conclusions of this research are problem-based learning should be developed in the field and can be use as an alternative option for the implementation of learning mathematics and making the suggested teaching materials in form of more challenging for students and inorder to exist trigger for cognitive conflict.

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