The Effects of Media based on Open Ended Problem to Enhanced Creative Thinking Ability

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Abstract: A quasi-experimental study with the pre-test post-test control group design was conducted to determine the effect of media based on open-ended problem in Problem Based Learning (PBL). The population of the study was students of grade VIII of Junior High School in Bandar Lampung city. Sampling was done by stratified purposive random sampling technique, to select one high-rank school and one low-rank school randomly from 31 schools in Bandar Lampung City. Furthermore, from each of the selected school, two classes were taken randomly. One class was the experiment group and one class was the control group. The experimental class obtained a PBL facilitated by media based on open-ended problem; meanwhile the control class obtained conventional learning. The research data were obtained through the test of mathematical creative thinking ability. The results showed that students' creative thinking ability in PBL facilitated by media based on open-ended problem at high-rank school and low-rank school had averaged 73.78 and 76.71 respectively. Students' creative thinking abilities in conventional learning had averaged 65.43 and 63.96, respectively. Hypothesis testing showed that there are significant differences in creative thinking ability between students in two group. So that the media based on open-ended problem in PBL has a positive influence on students' mathematical creative thinking ability

1 INTRODUCTION

Reformation in mathematics learning implies that students must be a self-directed learner. Independence in learning is an integrated learning process, containing a set of constructive behaviors that affect learning. Students can build a deep understanding of the content of mathematics to build their high-order thinking skills, if they can control the learning process. It can be obtained when the learning experience gives them the opportunity to do so.

Students' learning experience is largely determined by the learning activities designed by teachers and media used by the teacher. Therefore, the teacher should design the activity and choose the right model for the students. Selection of learning models and appropriate media will affect students' understanding of the subject matter. In mathematics, students 'understanding of the material being studied will affect students' understanding of the next material.

One of the abilities that is expected to be appeared on students after learning of mathematics is the ability to think creatively. This ability is very important about the student's ability to solve problems. Therefore, the development of these capabilities needs special attention in the study of mathematics, especially in junior high school. But in general, the ability to think creatively of junior high school students is still low. This is reflected in the low percentage of correct answers of students in the international studies Trends in International Mathematics and Science Study (TIMSS) and the Program for International Students Assessment (PISA). In the TIMSS study, the student is weak in solving non-routine problem related to justification or evidence, solving problems that require mathematical reasoning, finding generalizations or conjectures, and find relationships between data or facts provided. In the PISA study the student is weak in using mathematics to solve problems in everyday life. The development of creative thinking abilities needs serious attention, because several studies, for example (Henningsen,1997; Mullis et al, 2000) showed that the learning of mathematics in general are still focused on the development of lower stage of thinking skills. In addition, research (Noer, 2010a; Noer, 2010b; Noer, 2011; Noer, 2007a, Noer, 2007b)

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suggests that problem-based learning and open-endedlearning can be used to improve a wide range of mathematical skills, particularly in increasing mathematics high order thinking skills.

Addressing problems that arise in mathematics and hopes to achieve in mathematics, innovative efforts are needed to mitigate them. Students must be accustomed to construct knowledge and is able to transform the knowledge to other situations are more complex. In this way, the knowledge will be their own. One of the learning models that was chosen to address the problem above is problem-based learning (PBL). Hmelo-Silver (2004) said that PBL is a learning method that facilitates student learning through solving the problem at the center of learning. Issue raised in the PBL is complex and does not only have one correct answer (open-ended).Students work in collaborative groups to identify what they need to resolve the issue, involving students in independent learning, applying the knowledge they have on the issue, and reflecting on what they learned and how effective the strategy used. Based on the developed the model of learning media base on open-ended problem and learning tools to improve students' mathematical creative thinking ability.

2 METHODS

The population in this experimental research was all Junior High School students in Bandar Lampung city. Samples were determined using stratified purposive random sampling to select one high-rank school and one low-rank school. From a group of high-rank schools, subject sample was students of SMPN 19 Bandar Lampung. From a group of low-rank schools, subjects' sample was students of SMPN 22 Bandar Lampung. Furthermore, from these two schools, two classes are chosen; one class as an experiment class and one class as a control class. The two selected classes, previously tested, have the same initial ability using two similarity tests on average with the t test. Experiment class receives a PBL facilitated by media based on open-ended problems and control class receives a conventional learning. The media used is the student worksheet, which contains the activities of students to achieve the concept of mathematics through the PBL stage, which begins with the giving of problems that are open-ended both in the process of finding the concept and in the exercise. The subjects of this study were 106 students from two selected schools where selected randomly (51 student from experiment class; n1= 24, n2= 27; and 55 students from control class, n1= 24, n2= 27). Data were obtained through an essay test of mathematical creative thinking ability. This test is given to students before and after learning, either in the experiment class or control class. As an illustration, here is an example of the creative thinking problem used in this study.

"In a school, the road to the cafeteria is parallel to the road to the library, and the road to the teacher room is perpendicular to the road to the library. if the school plan has been made in the Kartesius-plane and the road to the cafeteria satisfies the equation: 2x - y - 10 = 0.

a. Determine the slope of the line that represents the path to the library?
b. If the teacher's room is in coordinates (7, 3), determine the equation of the line that represents the path to the teacher's room".

The student's answer score is based on indicator of creative thinking ability, i.e.: sensitivity, fluency, originality, flexibility, and elaboration. Before the test is used, instrument is tested first to find out the validity, reliability, distinguishing power, and difficulty level. Furthermore, to know the influence of media based on open-ended problem in PBL to creative thinking ability, then tested the hypothesis, that is test of difference of two mean using t-test. The results of statistical tests are interpreted and analyzed for conclusion.

3 RESULTS AND DISCUSSION

3.1 Result

Based on the data processing from the creative thinking ability test, obtained score of creative thinking ability of students as presented in Table 1. Table 1 show that the mean average score of students' mathematical creative thinking ability on high-rank or low-rank school that used PBL facilitated by media base on open-ended problem, higher than mathematical creative thinking abilities of students who received conventional learning.

Table 1: Creative Thinking Ability Score.

Research Group	MIS	n	x_{min}	x_{max}	$\bar{x}$	S
Exp -1	112	24	33	108	76.71	22.66
Cont-1	112	28	36	82	63.96	12.02
Exp-2	100	27	25	100	73.78	18.85
Cont-2	100	27	35	94	65.30	17.38

Note: Exp-1: experiment class on low-rank school
Exp-2: experiment class on high-rank school
MIS : Maximum Ideal Score

From the data that has been described in Table 1, then several hypotheses related to improving Creative Thinking Ability. For this purpose, the normality test and variance homogeneity test are first carried out. The test results show that the data on students' Creative Thinking Ability in the experimental class and control class for high-rank and low-rank schools are from the population not normally distributed.

Next, to test the average difference in creative thinking ability were used t-test. The hypotheses tested are:

H_0: $\mu_1 = \mu_2$ (There is no difference in the average of the two sample groups)

H1: $\mu_1 \neq \mu_2$. (There are differences in the average of the two sample groups)

Test criteria: Reject H_0 if with a significance level of 0.05, the value of t_{count} is greater or equal to the value of t_{table}. Summary of test results is presented in Table 2.

Table 2: t-Test Results Summary.

Rank School	Average of Creative Thinking Ability		t value	Sig.	Conclusion
	PBL	Conv.			
Low	76.71	63.96	2.47	0.02	H_0 Rejected
High	73.78	65.30	1.69	0.02	H_0 Rejected

Based on data presented in Table 2, the value of the probability (sig.) at low-rank school and high-rank school for both the learning model is smaller than 0.05. This means that the null hypothesis is rejected. This means that, there are significant differences between the scores of mathematical creative thinking abilities of students between the experimental group and the control group at both low-rank school and high-rank school. Given that the average value of creative thinking abilities of students in the experimental group was higher than the average value of creative thinking abilities of students in control group, it can be concluded that the average of creative thinking ability of students in PBL with media base on open-ended problem is higher than the average of creative thinking abilities of students in conventional learning.

3.2 Discussion

The results showed that student mathematical creative thinking ability in PBL higher than student mathematical creative thinking ability in conventional learning. This is in accordance with the characteristics of PBL. PBL describe learning environment which encourages learning problems. Learning begins with a problem to be solved. The problem posed is a means for students to gain new knowledge before they can solve the problem. In PBL, students interpret the problem; collect the information needed, identify possible solutions, evaluate options, and provide conclusions. Some experts in mathematical problem solving said that students would be a good problem solver by studying the mathematical knowledge heuristically. The successful experiences of students in managing their own knowledge also help them to solve math problems correctly (Schoenfeld,1985; Boaler, 1998). This is because the experience of students in managing their knowledge to solve problems will provide confidence to solve other problems, either relatively similar problems or more complex. Problem-based learning is the strategy classes that contain problem-solving activities and enable students to think critically, think creatively, and communicate with their colleagues mathematically (Krulik& Rudnick,1999; Lewellen& Mikusa,1999; Erickson, 1999; Carpenter et al, 1993; Hiebert& Carpenter, 1996;Hiebert et al,1997).

Another thing is the reason why students in PBL have better learning outcomes is the use of media-based on open-ended problems. Open-ended problem is a problem that has few or many answers correct. Through solving the problem, students are expected to understand the concept learned. Students are not only required to show the results of their work but are often asked to explain how they got the answer. When they use the open-ended based media, they discuss with their friends. This activity makes students more actively learn and dare to express their ideas, to solve the problem. An important goal in PBL is for students to be responsible for their own learning process. The PBL literature suggests that the development of self-directed learning can be used to improve content knowledge and encourage problem solving, communication and critical thinking skills (Hmelo-Silver, 2004). Schmidt et al (2011), also refers to studies that show that students in PBL become more self-reliant during the study compared to students who do not study with PBL.

Several studies have shown that PBL is effective in improving student learning, compared with the traditional teaching (Schmidt et al, 2012). In a study involving 47 students are enrolled in vocational nursing program (Mathews, 2011), found that problem-based learning increases students' knowledge and ability to apply that knowledge.

Kennedy (2007), found similar results in a study of the pathophysiology of students in advanced courses. Both of study compared PBL with traditional teaching methods and concluded that problem-based learning in order to improve the learning and application of learning it in other contexts.

Research shows that students' mathematical creative thinking ability in PBL facilitated by media base on open-ended problem is significantly better than conventional learning; both of high and low-rank school. This means that the learning approach and the school ranking influence the students' mathematical creative thinking ability. Students at high and low-rank schools are more successful in enhancing mathematical creative thinking ability in PBL that facilitated by media base on open-ended problem than students in conventional learning.

Some research on the application of PBL that strengthen and complement previous research on PBL, among others, research conducted by Abdullah et al (2010), that the study indicated that PBL is just as efficient as the conventional teaching strategy in enhancing the Form Four students' mathematics performance. Even though both groups of students have positive perceptions towards group work, interest in mathematics and perception towards the learning experience they went through, the PBL group used the Polya's problem solving procedures more effectively, presented better mathematical communication skills and showed stronger teamwork than to the conventional teaching group. Tarmizi and Bayat (2012), state that there are significant positive effects on the students' meta-cognitive awareness and on students' motivation level after undergoing PBL intervention. Malan et al (2014), state that Introducing PBL into a foundation program can develop self-directed learning skills in students and set in motion a process of growth towards lifelong learning. Padmavathy&Mareesh (2103), states that PBL should be adopted as an alternative instructional strategy to the Traditional Method in enhancing meaningful learning in PBL into the pre-service teachers' curriculum at the teacher-preparation institutions in Nigeria.

Based on the characteristics of PBL and conventional learning, it is fairness if there is a difference in the ability of students after following the lesson. PBL initiated its activities by presenting the contextual problems to the students. Then through group discussions, students organize their ideas and knowledge related to the problem, the students ask questions or issues around the problem. Students are given the opportunity to state what they understand and do not understand. The teacher looks at the course of the discussion and if necessary, the teacher can provide clues. In class discussions, these issues are discussed together, and students integrate new knowledge into the context of the problem. Teachers also remind students to reflect on what they have achieved. When time permits, presentations from several groups are accompanied by frequently asked questions.

The most dominant thing that causes the increasing of students' mathematical creative thinking ability is the use of media base on open-ended problem. The media in this study has given students the opportunity to hone their thinking skills. This ability is honed when students are faced with issues that are open and have a variety of ways or answers. Such problems make students try to find, recognize and answer the problem. This is in line with Hashimoto's opinion, (Silver, 1997) says that open-ended issues provide flexibility for students to come up with answers. In this way, students can acquire knowledge or experience of discovering, recognizing, and solving problems with several techniques. In addition to the use of a wide range of open-ended issues, it can improve students 'flexible in math capacities related to students' creative thinking abilities.

The media used in this study is an activity sheet which contains open-ended mathematical problems. This open-ended problem is done by students both in groups and individually. Through solving this open-ended problem, students' creative thinking activities can be facilitated. because the questions that are open ended, require students to be responsive to the problem, able to think in a variety of different ways, bring up new ideas and apply various knowledge they already have in solving problems, able to describe answers in detail, and be able to provide an explanation for the answer. This can be seen in observations during the study.

The success of students in PBL is in line with some research on the effectiveness of PBL and its benefits for students. From several studies on PBL, it has been concluded that there are two benefits to be gained: 1) related to student reflection and learning independence, and 2) positive affective results of PBL. Regarding student reflection and learning independence, PBL has shown cognitive and metacognitive advantages for students in the classroom. Downing et al (2009), concluded that PBL activities have been positively associated with metacognition development, directing students to self-study (Blumberg, 2000a; Blumberg, 2000b). Meta-analysis of the use of PBL in the classroom has shown that PBL is consistently positive for improving

student skills (knowledge application) and long-term knowledge acquisition (Dochyet al, 2003; Strobel & van Barneveld, 2009), better learning strategies and critical thinking (Sungur&Tekkaya, 2006; Stefanou et al, 2013), flexible knowledge and problem-solving (Hmelo-Silver, 2004). Related to the positive affective results of PBL; including increased student involvement in learning activities (Ahlfeldt&Sellnow. 2005); better learning effort, including time management, concentration and self-examination (Wijnia et al, 2011). Furthermore, PBL has also improved the value of secondary school students' tasks and intrinsic goal orientation compared with traditional instruction (Sungur&Tekkaya, 2006), higher social and academic integration, and satisfaction of their relationship with faculty and peers (Severiens& Schmidt, 2009). Hays & Vincent (2004) found that students in undergraduate psychology courses, rated that PBLs are good for promoting interaction between students and faculty. In addition, PBL is inspired by Piaget's different theoretical approaches as Piaget, Lewin, Negt, Vygotsky, Kolb, Lave & Wenger, Illeris(Kolmos et al, 2004). We have described how PBL holds some very interesting educational potential. Among others can be mentioned how students get motivated by working with real-life problems

Meanwhile, in the conventional learning the teacher explains the subject matter in detail, giving examples of ways to solve the problem. Students pay attention to the teacher's explanation, and then record what the teacher explained. Before the students take notes, the teacher usually gives the students time to ask questions about things that have not been understood. If any student asks, the teacher immediately explains the classical. Furthermore, the teacher gives students the exercise questions done individually. Meanwhile, teachers' pay attention to the way the students do the exercises and help guide the students who are experiencing difficulties. After completing the exercise, all students collect their work to the teacher for grading. For the discussion, some students are asked to work on the board.

In general, the implementation of learning with PBL at high-rank school and low-rank school has been running well. Based on the PBL format, the steps taken in the classroom learning are appropriate. This is reflected in group discussion activities, class discussions, questioning and responding activities, and presentation activities. All components in this lesson can be well executed. PBL is a new learning model for students and teachers in schools where the research is conducted. Therefore, in the first and second meetings, students are still confused and rigid in carrying out the activities of each phase contained in this lesson. But at the next meeting, the students are already accustomed, without being asked they have joined their respective groups to discuss the Student Worksheet (SW).

In the first phase of orienting students on the issue, the teacher asked several issues and activities that should be done by the students and the students try to understand the material by means of discussion. In the second phase, which is organizing the students to learn, teachers divide the students into groups consisting of 4 or 5 people are heterogeneous. In this activity, teachers distribute SW to each group and said that if students have difficulty, the students are given the opportunity to ask questions. Teachers emphasize the student to put his own group ideas on how to solve the problem. In the third phase of the investigation that lead individuals and groups, the teacher asks each group to resolve the issue in SW. During the discussion, teachers monitor to each group and directing students who have difficulty with Scaffolding techniques. It appears that each group actively discusses SW with discussion. This can be seen in Figure 1. In the fourth phase of developing and presenting the work, representatives from the group present the results of the group discussion, while the other group asks questions or responds if there are different answers. Figure 2 shows one of the group representatives presenting the results of the group discussion. In the fifth phase of analyzing and evaluating problem-solving processes, the teacher help students reflect on or analyze and evaluate their thinking processes and problem-solving results from phase 1 to phase 4. The use of open-ended media problems in this study provides an opportunity for students to practice their creative thinking skills. This can happen because open-ended problems require students to be sensitive to issues that give and think openly, be able to look at a problem from a different point of view, able to elaborate their understanding of the problem so as to obtain the correct answer (in phase 1 to phase 3), able to express its own original answer without hesitation (in phase 4 and phase 5). This experience gives students the opportunity to solve problems creatively.

Figure 1: Focus group discussions in the PBL.

Figure 2: Presentation of the group in PBL.

4 CONCLUSIONS

Based on the results of data processing on research conducted and discussion, it can be concluded that the use of media based on open-ended problem will facilitate the improvement of students' creative thinking ability. Therefore, the construction of open-ended problems is an important thing to be considered in learning. Problems are created with the aim of enabling students to look at things from different perspectives, to be more flexible to a thought or opinion. Media based open-ended problems need to be developed in a planned manner, such that through the open-ended problem students can understand the concept of mathematics well.

Based on these conclusions, the following suggestions can be put forward: (1) to the teacher, to improve mathematics creative thinking ability, it is advisable to use problem-based learning model in learning mathematics. Teachers could develop lessons plan and media base on open-ended problem to other materials, at the school and other grades; (2) to other researchers who want to develop advanced research on the application of problem-based learning model to improve students' mathematical creative thinking ability, should pay attention to the division of time in learning in order to obtain optimal results.

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