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EFFECTIVITY OF PROBLEM BASED LEARNING (PBL) IN IMPROVING STUDENTS' MATHEMATICAL REPRESENTATION

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Abstract

Mathematical representation skill is one of the goals in mathematical instruction especially in high school as well as college. Multiple representation skill is the ability to present a mathematical object (problem, statement, solution, model, etc) into a variety of notation that include (1) symbolic (algebraic form and formula); it is used in manipulating, interpreting, and operating with symbols, (2) visual: to interpret , to create, and to operate mathematical object in graph or images, (3) numerical: this is used to apply the procedure, to understand and implement the process, and to interpret the table. This study examined the effect of problem based learning in representation skills of high school students. Experimental design with pretest-posttest was applied to obtain the effect with involving 42 high school students who were studying at the third grade. Multiple representations of mathematical tests were designed to get the data. Quantitative and qualitative methods were applied to analyze the data. The result shows that problem based learning is effective to enhance representation skill of students.
Key Words: *Problem Based Learning (PBL), Multiple Representations, and Effectivity*

A. Background

One of the goals of mathematics learning is to develop abilities that involve (1) mathematical communication, (2) mathematical reasoning, (3) mathematics problem solving, (4) mathematical connections, and (5) mathematical representation (NCTM, 2007:7). According to Sumarmo (2005, these abilities are called mathematical power or doing math. Furthermore, Sumarmo stated that through mathematical skills is expected to meet of students' from now on to the future. The needs of today's learner are students understand the concepts needed to solve the problem of mathematics and other sciences when students are still attending school, while the future students is the students have ability to compete in community. Thus, mathematics learning is expected to enhance students' mathematical skills through mathematical task.

Committe on the Undergraduate Program in Mathematics aatau CUPM (2004), recommends that learning in the classroom should present key ideas and concepts from various perspectives such as presenting a wide range of example and application to motivate and illustrate the material, promoting mathematical connections to other sciences, to develop students' ability to implement in those materials, introducing the latest topic of mathematics and its applications, and improving students' perception about the role of mathematics in education.

Skills such as reasoning, communication, connection, and problem solving in mathematics requires a mean of communication (both verbal and written), expressed in a form of multiple representations, which is the language of mathematics that used to express ideas or toughts and to communicate it into other representations either verbally or writing through graphs, tables, figures, equation. However implementation of the learning process has difficulties; for example, students face difficulty to translate from one representation to another representation (Yerushalmy, 1997).

Many efforts have been done by developed country to find out the causes lack of ability of students in representations with educational theory, model of learning etc. Ferrini-Mundy and Graham (1993) says that in Calculus, students often feel dissatisfied with different results with different representations, and they are not always aware that these results are inconsistent, even contradictory. Similarly, Sfard (1992), Greer and Harel (1998), Hong, Thomas, and Kwon (2000), Greeno and Hall (in Zachariades, Christou, and Papageorgiou, 2002) says that students have minimal ability to bridge representations without understanding the common thread between the idea of the concept of the materials represented.

According to Janvier (1987), one of the lessons that provide many opportunities for students mathematical activity in conducting multiple representation is Problem-Based Learning (PBL) or Problem-Based Learning, which is a matter of learning that begins with an open (open-ended) in a contextual situation, the procedure is not well structured settlement (ill-structured), meaning that no algorithmic / procedural. Problem Based Learning is learning that starts with contextual issues and open, with the following characteristics: (1) the view of constructivism, with the formation of understanding through assimilation and accommodation of the issues presented, the discussion in solving problems, and experience experienced mathematical thinking; (2) student centered, the teacher as facilitator, motivator, and managers. Interaction among students and student-teacher takes precedence; (3) focuses on the linkages between disciplines.

Characteristics of problem-based learning allows students to engage in the learning process. In problem-based learning students are faced with a problem situation that requires them to analyze, collect information, see the causal relationship,and find a solution and reflect. The results of the analysis as well as information obtained through the given problem should be written, and then associated with the mathematical knowledge they already have before. Participation in these activities is expected to improve the ability of reasoning and communication skills. In addition, in problem-based learning students reinforce to provide and listen an opinion. All these activities will train them to get used to hear, comprehend and understand others. This will cultivate the courage, confidence, motivation and empathy that have an impact on the ability to manage emotions that produces an emotional intelligence.

Associated with problem-based learning, Delisle (1977: 7) states that PBL can be used by students in high school and even in college. This argument implies that the involvement of students with different levels will be possibly happened in PBL. This means that in PBL, students can be involved in analyzing the problem, gathering information to get the facts and then associating the facts with prior knowledge to obtain a settlement.

B. Research Questions

Based on the problems described above, the problem of this research is: how does problem-based learning can enhance students' representations?. This problem can be presented in more detail into several subproblems, namely:

1. How does the quality of students' representation using problem-based learning?
2. Are there changes of students' conception after students have been taught by problem-based learning?
3. Is the problem-based learning effective to reduce students' misconception and does problem based learning can improve students' ability in mathematics learning?

C. Goals

The goals of this research are

1. to obtain comprehensive description of the impact of problem-based learning on the ability of students' mathematical representation
2. to deeply examine if there is a change of students' conceptions about mathematical representation of students after problem-based learning
3. to get overview, is problem-based learning effectively reduce students' misconception and also students' performance in mathematical representations.

D. Benefits

The results of this study are expected to provide benefits to various parties, including:

1. For students, providing valuable experience through active involvement in the learning process, through analyzing the problem, gather information, look for a variety of alternative solutions and decide the most appropriate solution. These activities will be useful as a training event to prepare himself to face real-life challenges.
2. For mathematics teachers, to be able to apply the best form of representation for a particular topic material, so that students can better understand the concept of the material and become a useful reference for mathematics teachers. In addition, problem-based learning is an alternative approach that can be implemented in high school as well as college.

E. Methods

Experimental research has been applied to answer research's questions. This study will examine the effect of Problem-Based Learning to improve students' mathematical representation in high school. The method used in the form of experimental design with pretest-posttest design. Subjects were high school students in the third grade (42). Subjects randomly taken from the four classes. To obtain data, test which is essay format were administered to students. Before the tests are used, firstly, tests were examined to determine the validity, reliability, and difficulties level. Lesson plan also were given to students to support learning process.

The data were analyzed quantitatively and qualitatively. Before the data were analyzed, the scores obtained were tested normality to determine the appropriate statistical test. Based on normality test conducted, data is not normally distributed; therefore the analysis of the data for the second problem used non-parametric test (McNemar test).

Pretest \ **Postest**	**-**	**+**
+	**A**	**B**
-	**C**	**D**

(Sugiyono, 2007)

- Where the expected frequency E = ½ (A + D)

A = Number of students in which pretest and posttest completely wrong
B = Number of students in which pretest and posttest correct correct
C = Number of students in which pretest and posttest wrong wrong
D = The number of students in which pretest posttest dab correct erroneous

Furthermore, Effect Size test was used to analyze the third problem that determined the effectiveness of the treatment, Glass in (Sutrisno, 201).

rumus $\mathbf{ES} = \frac{M2-M1}{S}$ Glass dalam (Sutrisno,201)

S = Standard deviation M2 = average score Postes and M1 = average score pretest
ES magnitude criterias are classified as follows, namely:
ES ≤ 0.2: Relatively low
0.2 <ES ≤ 0.8: Moderate
ES> 0.8: Relatively High

F. Results and Discussion

1. Analysis of pretest and Posttest Quality

Pre-test was given to clasify students abolity in differen group like high, middle, and low students. In addition, it is also used to know students ability prior to the conduct the study. To obtain the quality of mathematical representation of students, conducted the mean and standard deviation analysis. The summary of mean and standard deviation of students' mathematical representation capabilities is presented in Table 4.1.

Tabel 1

Students' representation based on students' level

Students' level	Evaluation						Total		
	Pretest			Postest					
	Average	SD	n	Average	SD	n	Average	SD	n
High	17,30	3,08	10	22,00	3,09	10	19,65	3,08	10
Middle	15,28	2,92	23	20,26	2,91	23	17,77	2,92	23
Low	14,10	3,02	9	19,22	3,03	9	18,66	3,03	9
Total	15,56	3,01	42	20,49	3,01	42	18,69	3,01	42

The maximum score is 24

According to Table 1, the average pre-test is 15.56 of the ideal maximum score of 24, while the average posttest is 20.49. When viewed from the level of student achievement is high, medium, and low also increased.

2. Changes in students' conceptions about Multi-mathematical representation as Problem Based Learning

Based on the results of test calculations recapitulation changes Multi-mathematical representation of students after learning using problem based learning with the McNemar test, on each multi-criteria mathematical representations (symbols, graphs, and numerical / mathematical) and the overall value obtained $\chi 2$ count> $\chi 2$ table ($\chi 2$ count > $\chi 20,95$ (5) or 25.3> 11.1. This means that a change in students' mathematical understanding of multi-representation.

3. Effectivity of Problem Based Learning to cope students' misconceptions and enhance Multi mathematical representation of students in learning mathematics

From the calculation of the effectiveness of using the formula Size Effect where the average pretest was 15, 56 and the average post-test of 20.49 is being value S = 3.01 using formula **ES =** $\frac{M2-M1}{S}$ = (20,49-15,56) / (3.01) = 1.64 is high. So that effective problem-based learning to improve students' mathematical representation multi.

G. Discussion

The results showed that problem-based learning is effective to improve students' mathematical representation based on multi-level and overall student achievement. According Tall (1995) in mathematical thinking, someone will be faced with an object (a problem in the form of numbers, symbols, statements, or other) in a learning environment, and it will have a perception of this object and perform an internal process to an action. This action in the form of a visuo-spatial representations (images or graphics, which will be the verbal-deductive) through an object, or in the process of-concept with a conceptual link between them. Problem-based learning that begins with the real concept enables students to more easily understood better when working in groups as well as classical. Each student is required to undertake the completion of a variety of practice questions that had been prepared in the work sheet. PBL models can facilitate the conceptual change on students because of cognitive conflict through the exposed concrete problems.

The findings show that there is a change in the students' misconceptions in understanding mathematical representation. Problem Based Learning can facilitate students' conceptual change because this model gives students opportunity to syntesize the concept. The

PBL group shows significantly higher in FCL conceptual learning gains than the traditional group. Problem-based learning can facilitate changes of student misconceptions about multi mathematical representation for problem-based learning poses a challenge for students to develop a strategy to prove his hypothesis. Once the strategy is used, the teacher role is to support students in syntesizing of new concepts through questions support (scaffolding)

The effectiveness of problem-based learning is also effective for improving student learning outcomes in understanding multi mathematical representation. These findings provide an opportunity for researchers to apply the problem-based learning in a variety of problems in mathematics.

Problem-based learning has three characteristics, namely: a lesson focuses on solving the problem, the responsibility for solving the problem rests on the students, and teachers support the student while working the problem (Eggen & Kauchak, 2012). Thus, problem-based learning facilitates students to construct their own new concept which is more suitable to describe the experience to remediate their misconception. The effectiveness of problem-based learning is also influenced by: first, the lesson begins with a problem and solve the problem is the purpose of the lesson; second, the student is responsible for formulating strategies and solve problems. Learning is done in groups, which is quite small (no more than four) so that all students are involved in the process. The teacher directs students to be responsible for formulating strategies and solve problems. Third, the teacher guides the student attempts to ask questions and provide support in learning when students try to solve the problem.

Support of teachers in problem-based learning should be carefully considered. This characteristic is important and requires professional skills and judgment to ensure the success of problem-based learning. If the teacher does not provide enough support and guidance, the student will be fail, wasting time, and may have misconceptions. If teachers give too much support and guidance, students will not get a lot of experience solving problems.

H. Conclusion

Based on the analysis, there are several conclusions:

1. Problem-Based Learning can improve students' mathematical murepresentations based on the level of achievement as well as a whole. The quality of problem-based learning is also viewed when learning takes place with activity and enthusiastic student motivation in asking and diligent in working in groups.
2. There is a change in students' conception in understanding of mathematical representation based on the initial achievement level of students as well as overall. The most noticeable changes occurs in the multi mathematical representation in drawing or graph of a function and mendeskripkan in mathematical equations.
3. Based on the obtained value of Sais-effect can be concluded that the effectiveness of problem-based learning is high enough in improving student learning outcomes by level of achievement as well as a whole. This means problem-based learning is effective mathematics learning especially in functions topic.

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