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Mathematical representation ability of students' grade X in mathematics learning on problem based learning

Palupi Retno Utami[a,*], Iwan Junaedi[a], Isti Hidayah[a]

[a] *Mathematics Department, Science and Mathematics Faculty, Universitas Negeri Semarang, D7 Building 1st Floor, Sekaran Campus, Semarang 50229, Indonesia*

** E-mail address: palupiru.4101412013@gmail.com*

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Abstract

The purposes of this study were to obtain a description of learning quality on problem based learning to improve the mathematical representation ability of students grade X and to get description about mathematical representation ability of students grade X in mathematics learning on problem based learning. This study used a qualitative method. It is procedure of study that produces descriptive data in the words or oral from people and behavior that can be observed. The study was conducted at SMA 1 Bumiayu with the students of X MIPA 6 as the subject. Additionally, the subject of this study was students and teacher. The chosen students were selected as many as 6 persons which are 2 persons from upper group, 2 persons from medium group and 2 persons from lower group. Eventually, the result showed that (1) the quality of mathematical learning on problem based learning was in good category, (2) the mathematical representation ability of students in each group was different. For more, words representation and mathematical expressions ability showed a uniform pattern, while the visual representation ability showed diverse pattern.

1. Introduction

Education as one of the parameters of a nation's progress makes educational standards as a predictive tool for long-term prosperity of a country. A quality education can also create quality human resources. To create a quality education system, proper learning is urgently needed, so that students are able to develop their potentials to have religious spiritual strength, self control, personality, intelligence, noble character, and the skills needed by themselves, society, nation, and country. One subject that can be used to achieve the goals of national education is mathematics.

Kline in Suyitno (2008) say that mathematics is a symbolic language. Mathematics as one of the compulsory subjects in the school as explained in the Act of The Republic of Indonesia Number 20 of 2003 concerning the national education system which states that "every student who is in primary and secondary education must take mathematics lesson" has an important role in realizing goals of national education. The role of mathematics in the life society is considered as the main reason for the importance of learning mathematics. The importance of mathematics as a science that must be learned in school, it requires an appropriate mathematics learning, so that mathematics can be learned properly and functionally used in daily life.

The National Council of Teachers of Mathematics (2000) sets out 5 process skills that students must possess in learning mathematics which is summarized in process standards, namely (1) problem solving, (2) reasoning and proofs, (3) communication, (4) connection and (5) representation.Those process skills are the part of the ability of high order mathematical thinking. Therefore, a proper learning is highly needed so that students' mathematical skills can develop and improve. Besides, this study will only discuss about the mathematical representation ability of students.

According of Sunaringtyas (2017), the ability of high order mathematical thinking can be done by improving the quality learning. A good quality

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learning can stimulate students' learning so they can improve their mathematical abilities.

According of Hwang (2007), mathematical representation is a description of the relationship between object and mathematical symbols. Mathematical representation is needed by students to communicate mathematical ideas in various ways. The good mathematical representation ability will help students to model and interpret a mathematical problem so that a solution of the problem can be found. Kholiqowati (2016) explains that the selection of the good representation is very important to make an accurate mathematical problem solving strategy. The good mathematical representation will be able to simplify a complex problem into an easy problems. In the end, a solution can be found. On the contrary, an incorrect mathematical representation ability can also mislead students' thinking the simple problems can be complicated and difficult to find solutions.

Based on Hudiono's research (2010), as many as 86,36% of high school students were still can't be improve their ability of mathematical representation. In the case study, Hudiono argues that the ability of high school students to represent mathematical problems is still limited to symbolic representation, especially arithmetic. The result of the case study presented by Hudiono is then supported by reasearch conducted by Safitri. She (2015) states that the representation ability of high school students is classified as medium in iconic representations and classified as low in enactive and symbolic representations. The weakness of representation ability of high school students according to Hudiono said that one of which is caused by learning mathematics that is less interactive. Teachers in high school generally teach representation is limited to conventional ones, where teachers provide formulas and students imitate the teachers, students are rarely given the opportunity to present their own representation.

Safitri (2015) conducted a study by analyzing of representation ability which included enactive representation, iconic representation and symbolic representation. Representation abilities that analyzed by Safitri are representation ability that proposed by Bruner. While in this study, the researcher analyzed the representation abilities proposed by Mudzakir which included representations of words, visual representations and representations of mathematical expressions.

In a study conducted by Hudiono (2010) the analysis of mathematical representasion ability of the students use a quantitative methods. Whereas in this study, mathematical representation ability of the student was analyzed by qualitative methods. So the difference between this study and the previous research conducted by Hudiono is the method that used by the researcher.

According of Hudiono's reasearch which states that the ability of mathematical representation of high school student is relatively low. Based on the of observations that be held in SMA 1 Bumiayu on February 2016, it was found the fact that mathematics learning conducted in the classroom tend to be less interactive in which the teacher explains and students listening. Based on observation, the teacher had not explored the mathematical representation abilities of the students, the teacher provided formulas which then imitated by the students, so that students were only solving the problems that had been exemplified by the teacher. According to Krulik and Rudnick in Hidayah (2016), a teacher will become a coreographer who designs activities in which students could get necessary experiences to develop their mathematics abilities. Therefore, it is urgently needed the learning that can improve the students' mathematical representation abilities.

According to De Porter and Hernacki in Mulyono (2018), learning style is one of the important variables in the way students perceive the lessons in school. One of the learning model which is considered to be able to improve students' learning and mathematical representation ability is problem based learning. In problem based learning, students are given math problems related to daily problems. Mathematical problems in the tasks are expected to create situations and circumstances which are familiar for students so that they are automatically able to find the mathematical concept they learn. Zain (2015) says that problem based learning focuses on the main principles and concepts of a discipline, involves students in solving the problems and other meaningful tasks, and encourages participants to work independently constructing their own learning. In problem based learning the method used is an interactive method. According to Izzati (2012), through this interactive method of problem based learning, students get the opportunity to train how to communicate ideas, strategies or procedures for resolving a problem both verbally, in writing and drawing.

Based on the explanation above, there are several objectives of this study, as follows (1) to obtain a description of the quality of problem based learning (PBL) whether it can improve the mathematical representation ability of class X students or not and (2) to obtain a description of the mathematical representation abilities of class X students in problem based learning.

2. Methods

This study used a qualitative method. According to Bogdan and Taylor in Moleong (2002), qualitative method produces descriptive data in the form of written or words from people and their behavior. The data used in this study included the data regarding to the quality of learning and students' mathematical representation ability.

The subjects which were selected in this study were 6 students of class X MIPA 6 SMA 1 Bumiayu. Particularly, they were chosen 2 from the upper group, 2 from the medium group and 2 from the lower group. It was done based on the results of the students' last daily tests. The test was conducted based on Arikunto's (2013) opinion, they are as follows, (1) summing the scores of all students, (2) finding the mean (standard) and standard deviation and (3) determining group boundaries in which the upper group was all students who got the score as much as the average score plus one (or more) standard deviation, the medium group was all students who got the score between -1 SD and +1 SD and the lower group was the students who got the score -1 SD and less than -1. The decision to take 6 students as the subject of this study was determined through purposive sampling technique. Sugiono (2012) argues that in purposive sampling, the data source sampling was carried out with certain considerations. The consideration referred to the unique answers from the given mathematical representation ability test.

The data collection methods of this study consisted of documentation method, observation method, mathematical representation abiliy test and interviews. The data which were taken through the documentation method were the results of the mathematical representation ability test, the worksheet of the students', and the data of the formative test result of the students at the end of each lesson. In addition, there were several photos as the documentation during the implementation of the learning process using PBL models and sound recordings of interviews. The observation was carried out by observing the activities of the teachers and students during the mathematics learning on problem based learning. The test was an essay test to determine the mathematical representation abilities of students. In the interview, researchers used interview guidelines in the form of outlines of the problems to be asked.

The technique of data of this study includede data reduction, data display and conclusion drawing/ verification. The data reduction activities were in the form of classifying, directing, disposing of data which were not needed, organizing the data which had been reduced to provide a picture of the observations and made it easier for researchers to find the data needed any time. For more, the simplification which was carried out included the simplification of interview results only based on necessary to determine the level of students' mathematical representation abilities so that things which were considered unecessary were not included. Then, the data display was conducted after the data were reduced. In this study, the data display which was carried out included the classification of mathematical representation ability data based on the results of students' mathematical representation ability test and interviews. Conclusion drawing was done from the display data presented . If the display data had been supported by solid data, it could be a credible conclusion. Conclusion drawing in this study was taken from the observation data of the students and teacher activities, the results of mathematical representation ability tests, and the data from the interview that was by comparing the results of mathematical representation ability with the results of interviews through triangulation techniques to conclude students' mathematical representation ability level.

3. Results & Discussions

3.1. Quality Learning of Problem Based learning

Mathematics Learning on problem based learning is considered to have a certain quality if the planning and the implementation of the learning process is in good category, and the assessment of learning outcomes shows that more than 75% of the students fulfill the minimum criteria that have been set.

The planning of the learning process includes the preparation of making learning tools namely syllabus and lesson plans. The assessment of the learning tools was carried out through validation

by experts consisting two mathematics lecturers and a mathematics teacher from SMA 1 Bumiayu. The assessment provided by the validator referred to the rating scale. The scale that used contains 5 categories, there are (1) poor, (2) unsatisfactory, (3) average, (4) good and (5) excellent. Before the learning tools were validated by the validator, the learning tools have been revised several times according to the supervisor. The syllabus component included identity, core competencies, basic competencies and indicators of mathematical representation abilities, learning activities, assessment, time allocation, media and learning resource. There are five assessment aspects in syllabus validation, these five aspects are (1) syllabus component, (2) learning activities, (3) assessment techniques, (4) language and (5) time. The results of the syllabus validation can be seen in table 1.

Table 1. The Result of Syllabus Validation

	Score	Precentage	Category
Validator 1	37	82,2%	Good
Validator 2	38	84,4%	Excellent
Validator 3	37	82,2%	Good
Total	112	82,9%	Good

Based on the Table 1, it can be seen that the acquisition of the final total score of the syllabus assessment is 112 with a precentage of 82,9%. Therefore the syllabus is in a good category, as a result it can be used for learning.

The lesson plan component includes identity, core competencies, basic competencies and indicators of mathematical representation abilities, learning objectives, teaching materials, learning methods and models, learning steps, learning resource and learning media, assessment and student worksheets. Before being validated, the lesson plan has been revised for several times as the supervisor suggested. The lesson plan of learning is assessed based on five aspects of assessmet, as follows (1) formulation learning objectives, (2) lesson plan components, (3) PBL activities, (4) language and (5) time. The validation results of the lesson plan from the validator are presented in Table 2.

Table 2. The Result of Lesson Plan Validation

	Score	Precentage	Category
Validator 1	94	81,7%	Good
Validator 2	96	83,5%	Good
Validator 3	94	81,7%	Good
Total	284	82,3%	Good

From Table 2, it is obtained the information that the acquisition of the total lesson plan final score is 284 with a precentage of 82,3%, therefore the lesson plan is in a good category so that it can be used for learning.

The implementation of the learning process includes teacher activities and students activities in problem based learning. The assessment of taecher and students activity on problem based learning was carried out through observation by using observation sheets. Observation were conducted by a math teacher and students of the university. The assessment results from the observation sheet of teacher activity and student activity were then analyzed based on the final score obtained.

The teacher activities assessed were from the beginning till the end of learning. There are three aspects assessed in the assessment of teacher activity. It consists of preliminary, core and closing activities. The results of observing teacher activity on problem based learning are presented in Table 3.

Table 3. The Results of Teacher Activities Observation

The code of observer	Score			Average
	Meeting 1	Meeting 2	Meeting 3	
Obs. 1	102	104	105	103,6
Obs.2	109	109	110	109,3
Final average	105,5	106,5	107,5	106,5
Precentage	87,9%	88,7%	89,6%	88,7%

The table shows that the teaching on problem based learning with the final average of 106,5 and the precentage was 88,7% which means that the activity or performance of teachers in mathematics learning on problem based learning is in excellent category.

Meanwhile, the students' activity was assessed based on mathematics learning model of problem based learning which was contained in lesson plan. The assessed activities included students' activities from the beginning to the end of learning. There were preliminary, core and closing activities. The assessment is presented on the following table.

Table 4. The Results of Students Activities Observation

The code of observer	Score			Average
	Meeting 1	Meeting 2	Meeting 3	
Obs. 1	87	90	88	88,3
Obs.2	94	93	96	94,3
Final average	90,5	91,5	92	91,3
Precentage	86,2 %	87,1%	87,6%	86,9%

Based on Table 4, it was found that the teaching on problem based learning with final average of 91,3 and the precentage of 86,9% which means that the students' activities in mathematics learning on problem based learning model had excellent category.

In this study, the evaluation of learning was assessed based on students' work in completing students worksheets and formative test. In the assessment of group work result, it shows that the average results of the group at each meeting is 85,04 which means that it has fulfilled the clarity because 100% of students get more than 75 which is the minimum criteria of mastery learning or *KKM* which previously have been set. Then, for formative tests which were conducted individually at the end of each meeting, the average score obtained by each student in each meeting was 80,9 with many students who got an average score above the passing criteria of the least 31 students from 34 students. It means there were at least 91,2% students who got an average score above the passing. Based on that finding, the evaluation of learning is categorized having certain quality since more than 75% of students fulfilled the classical completeness that has been set.

Based on the result of the syllabus validation in the problem based learning, it is obtained that the final acquisition was 112 with a precentage of 82,9%, therefore the syllabus was included in the good category. The results of lesson plan validation on problem based learning obtained information that the final acquisition was 284 with a precentage of 82,3%, so the lesson plan was included in the good category. Thus, the planning of the mathematics learning on problem based learning has been well implemented, it goes without saying that it is worthy to use.

Based on the assessment of teacher and students activity which was measured by using observation sheet, it reports that the final precentage of teacher's activity by 88,7% means that the teacher's performance in mathematics learning on problem based learning is in the excellent category. While students' activities final precentage was 86,9%, it means that the students activities in problem based learning were included in the excellent category. In brief, the implementation of the mathematics learning on problem based learning has been implemented very well.

Further, based on the result of group work assessment, it is obtained that the average of the final score for all groups was 85,04 which means that it has successfully fulfilled the classical completeness with a percentage of 100%. Whereas from the result of formative test assessment which was done individually, the average value of students in each learning was 80,9 with a percentage 91,2% students who reached the Minimum Mastery Learning Criteria. Then, the result of group activities and formative test students shows that the evaluation has certain quality learning since more than 75% students have fulfilled the classical completeness that previously has been set.

Based on the learning quality indicators which include planning of the learning, the implementation of learning process and learning evaluation, it can be concluded that mathematics learning on problem based learning is in good quality so that it is worthy to use. The description of the learning quality indicators in this study is that planning of the learning is in good category, the implementation of the learning process is in excellent category and learning evaluation shows that > 75% of the students fulfilled the minimum mastery learning criteria.

In the mathematics learning on problem based learning, there are several phases which can improve students' mathematical representation abilities. The phase is phase 2, phase 3 and phase 4 of the PBL syntax, that is organizing students to learn, guiding individual and group investigations and developing and presenting the work. In the phase of organizing students to learn, there are group discussions with worksheet to solve the given mathematical problems. These activities are able to facilitate the development of students' mathematical representation abilities through information exchange between group members. In phase 3 and 4 namely guiding individual and group investigations and developing and presenting the work, there is a question and answer activity between students and teachers regarding issues that have not been understood and the

activities of presenting the results of group discussion in front of the class. The activity is expected to be able to improve students ability to represent the words through the disclosure of their ideas orally.

These results are in accordance with Sunaringtyas (2017), that is the quality of problem based learning is included in the good category, so it is worthy for use. The difference is that the mathematical ability which is analyzed through problem based learning is the students' creative thinking ability, whereas in this study the mathematical ability is students mathematical representation abilities.

3.2. Mathematics Representation Ability

To find out the students' mathematical representation ability, this study used a mathematical representation ability test instrument and interview. Mathematical representation ability test was conducted in the form of descriptions to identify students' mathematical representation ability. While the interview was conducted semi openly to ensure students' mathematical representation abilities.

The selection of the subject was based on the last daily test conducted by students of class X MIPA 6 which were then grouped into upper, medium and lower group students. Based on the results of the mathematical representation ability test, the researcher selected 2 students from the upper group, 2 students from the medium group and 2 students from the lower group to be the subject of this study. The subjects of the study were selected based on the results of their answers in the mathematical representation ability test that had been done previously.

The results show that each group has several differences. From the upper group; first, on the indicator of writing interpretation of a representation, the ability of the upper group on shows uniformity that is good and excellent. Second, on the indicator of writing mathematical completion steps with words, it shows the diversity that is average, good and excellent. Third, on the indicator to answer the question by using words, it shows the diversity, that is average and excellent. It means that the ability of word representation of the upper group is in an excellent category. Fourth, on the indicator of making the equation or mathematical model of the other representation given, it shows uniformity namely good and excellent. Fifth, on the indicator of solving problems that involve mathematical expressions also shows uniformity that is good and excellent, so that the ability of mathematical expression representation of the upper group is at good category. Sixth, on the indicator of restating data or information from another representation to graphical representation also shows uniformity that is good and excellent category. Last, on the indicator to use visual representation to solve the problem shows diversity that is average and excellent, so that the ability of the visual representation of the upper group is at good category.

Then from the medium group; first, the ability of the medium group on the indicator to write the interpretation of a representation shows diversity that is average and excellent. Second, on the indicator to write mathematical completion steps with words shows diversity that is average, good and excellent. Third, on the indicator to answer questions using words shows also diversity that is average and excellent means that it is at good category. Fourth, on the indicator to make mathematical equations or models from other representations given shows diversity, that is average, good and excellent. Fifth, on the indicator to solve problems involving mathematical expressions also shows diversity that is unsatisfactory, average, good and excellent, so that the ability of mathematical expression representation of the medium group is at good category. Sixth, on the indicator to restate data or information from another representation to graphical representation shows diversity that is unsatisfactory, average and excellent. Seventh, on indicators to use visual representation to solve problems shows also diversity that is unsatisfactory, average and excellent, so that the ability of visual representation of the medium group is at average category.

Lastly from the lower group, on the indicator to write the interpretation of a representation shows uniformity that is good and excellent. Then, on the indicator to write mathematical completion steps with words, answer questions using words; make equation or the mathematical model of other representations given; and solve problems involving mathematical expressions show diversity that is unsatisfactory, average, good and excellent, so that the ability of the mathematical expression representation of the lower group on those indicators is at good category. While the ability of the lower group on the indicator to present data or information from a graphical representation and use visual representation to solve problems shows

diversity that is poor, unsatisfactory and average, in other words, the ability of the lower group on those indicators is at average category.

Regarding to the results, the representation abilities analyzed in this study include visual representation, representation of mathematical expressions, and word representation in each group have a different levels. The level of mathematical representation ability of the subject of the study is presented on Table 5.

Table 5. The ability of mathematical representation of the subject of the study

	WR	RME	VR
Upper Group	Excellent	Good	Good
Medium Group	Good	Good	Average
Lower Group	Good	Good	Average

Note:
WR: Word Representation; RME: Representation of Mathematical Expression; VR: Visual Representation.

Based on Table 5, it was found that the ability of each group of subjects shows different levels.In the words representation and representation of mathematical expression, the level of ability of the upper group, medium group and lower group there is no difference that is in the good category, while in the visual representation, there are different levels of each group.

After analyzing the mathematical representation ability of the students from the results of the test and interviews and the results of the triangulation of each subject in each category, it is found that first, on the subjects in the upper group, the ability of words representation is in the excellent category, the ability of visual representation and mathematical expression representation are in good category. Second, on the subjects in the medium group, the ability of word representation is in the good category, the ability of visual representation was in the average category, while the ability of mathematical expression representation is in the good category. Third, on the lower group subjects, the ability of word representation is in the good category, the ability of visual representation is in average category, and the ability of mathematical expression representation is in good category.

Shortly, in the word representation and mathematical expression representation abilities, the description of the ability of the upper, medium and lower groups is no difference, the three are in the excellent and good categories, while the visual representaton abilities shows different category in each group. In the ability of word representation, the pattern uniformity seen in the research subject; the upper group, medium group and lower group, is almost every student wrote what was known and asked and wrote the steps and conclusions. In the representation of mathematical expression ability, students also showed uniformity by writing mathematical model and solving problems by using mathematical models that have been made, although their answer were still wrong. In visual representation abilities shows the diversity, students from upper group were able to provide graphs of the questions posed, even though the graphs were sometimes irrelevant, while lower group was also less able to graph of the task, some even did not draw the graph at all on the answer sheet.

Eventually, the results of this study are in accordance with the results of research conducted by Hudiono (2010) that the ability of mathematical representation in high school students has different levels. However, in Hudiono's research, student weakness lies in symbolic representation, while in this study students are still weak in the ability of visual representation.

4. Conclusion

Based on the findings and discussion, the researcher obtained the following conclusions, as follows (1) the quality of mathematics learning on problem based learning is in good category. In planning the learning process, there are validation of syllabus and lesson plan are also included in good category. In the implementation of learning process which includes teacher and student activity is in excellent category and evaluation or assessment of learning result get average score more than 75% of students who fulfill the minimum mastery learning criteria, (2) the mathematical representation ability in every groups is different. Words representation and mathematical expression ability show a uniform pattern. While on the visual representation ability shows a diverse pattern. One of the factor of differences in the visual representation caused by the different ability of students to change mathematics expression into graphic form.

Based on these conclusion, the researcher suggests that learning in groups to assist in order to

improve the ability of mathematical representation, so that students who are in excellent category on mathematical representation ability can help the other students who are in poor and average category. Finally, this study is expected can be a reference to other studies which analyze about mathematical representation ability on other materials. In the end, the mathematical representation ability of students can be described with extensively.

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