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Analysis of the Mathematical Communication Ability of Grade X Student on the Logarithmic Functions

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Abstract. This research aimed was describing the mathematical communication skills of the grade X Science students in Yogyakarta after following the process learning and using Problem Based Learning on the logarithmic functions material. This research was conducted in one of the high schools in Yogyakarta at October 2017. The type of this research was the design research. The subjects of this research were grade X Science students in Yogyakarta. The steps undertaken in this research were initial design, test and implementation of learning. Data analysis used in this research were data reduction, data presentation and conclusion or verification. In this research, there were 5 students as subjects, but the researcher will only describe 1 subject. The results are analyzed based on students' performance indicators set by the NCTM. The results showed that (1) The student was able to use the ability in using the terms, mathematical notations and structures to present the idea by using the definition of logarithm, (2) The student was also able to understand, interpret both orally, and writing, or in another visual form, (3) The student was able to use the ability to demonstrate and describe through oral and written.

Keywords: PBL, Mathematical Communication, Logarithmic Functions.

INTRODUCTION

The process standards, which is the ability that students must possess to achieved are: (1) mathematical problem solving, (2) mathematical reasoning, (3) mathematical communication, (4) mathematical connections, and (5) mathematical representations [1]. Based on this, mathematical communication couldn't be separated from mathematics learning. According to Baroody there were two reasons why mathematical communication is important, that were: (1) mathematics is a language, mathematics is not just a tools. Mathematics helps to find patterns, solve the problem, but also (2) mathematics as a social activity in learning mathematics [2]. Based on the results of interview with teacher of mathematics subjects related to the logarithmic functions material, students still have difficulty in transforming the shape of exponents into logarithms, especially if the questions of the problem was rather complex. Students were also accustomed to solving problems that weren't in the questions of a story problem. When students were given a story problem, students couldn't prove it. This students cannot do because students weren't guided by the previously taught concept. In mathematical communication skills, teacher said that students who have higher ability were able to communicate mathematically because at the time of group discussion, students with higher ability were responsible for teaching their friends and when presenting the results of the discussion to in front of the class, the teacher will surely appoint the lower ability student so that the student was able to communicate what they were studying. Based on the background, the research question in this research was how the mathematical communication skills of the grade X Science students in Yogyakarta after following the process learning and using Problem Based Learning on the logarithmic functions material?

THE COMMUNICATION MATHEMATICS, PROBLEM BASED LEARNING, DESIGN RESEARCH

Communication is an activity where students can express mathematical ideas and assess their accuracy using language. Students are given the widest opportunity to speak, write, read, and listen [1]. On the other hand Clark stated that "*Math is communication. You have to be able to communicate the concepts. You have to be able to communicate your thinking. Numbers are not enough for any good mathematician. You have to prove. You have to convince*" [3]. This indicated that the students must be able to convey the contents of their thoughts on math problems, not only in terms of counting but also how to communicate the mathematics both orally and in writing.

Opinions about mathematical communication is also expressed by Schoen, Bean and Ziebarth [2]. They argued that mathematical communication is the students (1) ability to explain an algorithm and a unique way of solving problems, (2) ability to construct and explain real-world phenomena in graphs, sentences, equations, and tables or other physical form of presentation, and (3) ability to give conjecture about the pictures of geometry. Furthermore, NCTM suggests that indicators of mathematical communication competency in mathematics learning comprises of: (1) ability in using the terms, mathematical notations and structures to present the idea by using the definition, (2) able to understand, interpret both orally, and in writing, or in another visual form, (3) able to use the ability to demonstrate and describe through oral and written [1].

Therefore, the suitable learning model for this research is the Problem Based Learning model. Boud & Feletti on 1991 stated that Problem Based Learning model, is a learning model that makes the problem as a basis for students to learn. The basic principle supporting the concept of PBL is older than formal education itself, namely that learning is initiated by a posed problems, query, or puzzles that the learner wants to solve [4].

According to Gravemeijer & Van Erde on 2006, design research is a research method that aims to develop Local Instrument Theory (LIT) with cooperation between researchers and educators to improve the quality of learning. Design research can be characterized as: (1) intervetionist: the research leading to the design of an intervention in the real world, (2) iterative: the research incorporates a cyclic approach to the design, evaluation, and revision, (3) process-oriented: a model of research that avoids the measurement of inputs and outputs, focus on understanding and improving interventions, (4) oriented to usability: the benefits of design were measured by looking at the practicality of the design for the user in reality, and (5) oriented to the theory: design (at least partially) made by theories that already exist, and field testing of the design contribute to the development of the theory [5, 6].

METHOD

The type of research used in this research was the design research developed by Gravemeijer and Cobb. According Gravemeijer and Cobb, the design research was divided into three stages: (1) preparing for the experiment, (2) design experiments, and (3) retrospective analysis [5].

The subjects of this research were grade X Science students in Yogyakarta. Research was carried out at the first semester of 2017/2018 school year. In this research, data was collected by documentation method. Data from the study were recorded learning video and documentation of the students working results.

In planning learning design, researchers also make a conjecture students reaction during learning and the strategies which would be used by students. Gravemeijer stated that the learning hypothesis is activity hypothesis everyday in the designed learning [7].

Data analysis technique in this research was conducted in a qualitative descriptive. In this research, data reliability was measured through a description of the learning process which is carried out by the researchers. The used steps in data analysis were: 1) data reduction which means to summarize, choose things, focus on the important things, look for themes and pattern and discard unnecessary information; 2) data presentation which is a set of well-structured information giving the possibility of withdrawal of conclusions; and 3) conclusion or verification which is intended to find the meaning of the data collected by finding relationships, similarities, or differences.

RESULTS AND DISCUSSION

Problems test was given to students after applied PBL, then the test results will be analyzed based on 3 indicators of communication mathematics ability. The PBL problems which was given in applying PBL were the problem of compound interest and the number of times the ball falls to construct the ability to define a logarithmic function. In this research, there were 5 students as subjects, but the researcher will only describe 1 subject. The following is an analysis of student's mathematical communication ability after PBL applied:

1. **Ability in using the terms, mathematical notations and structures to present the idea**
Q1

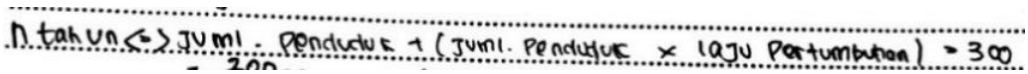

Figure 1. first part of student's answer for Q1

In question number 1, the student has been able to use the terms, mathematical notations and structures to present his ideas. This is seen in student assignment. For using the terms, student has been able to write n years to state after how many years the population will increase. But, even though the student can express his idea explicitly, the idea of the student in solving the problem was still incorrect because $(population \times growth\ rate)$ should be on the power of n. For the use of notation, the student used if and only if notation in expressing formulas using words, and "=", "()", "+", etc. It's also seen when researchers interviewed the student, and the student can explain it. Researchers ask:

R: "What did notation you use?
S: "I used notation plus, equals, in parentheses, if and only if, and so on".

Q2

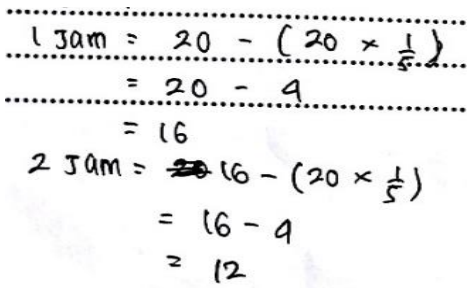

Figure 2. first part of student's answer for Q2

In question number 2, the student has been able to use the terms, mathematical notations and structures to present the ideas. This is seen in student assignment. For using the terms, this student has been able to write 1 hour to state the length of the brownies after the first piece, etc., but the student doesn't stated the idea explicitly as he did for question number 1. The student can use mathematical notation well like "=", "()", etc. It's also seen when researchers interviewed the student, and the student can explain it. Researchers ask:

R: "What did notation you use?
S: "I used notation multiplied by, equals, in parentheses, minus, over, and so on".

2. **Ability to understand, interpret both orally, and in writing, or in another visual form**
Q1

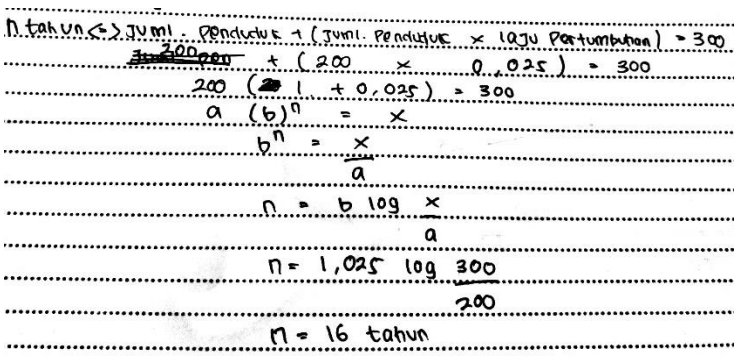

Figure 3. second part of student's answer for Q1

In question number 1, the student has been able to understand, interpret both orally, and in writing, or in another visual form. This is seen in student assignment which is student was able to understand by writing what was known and his answer is correct. It's also seen when researchers interviewed the student, and the student can explain it. Researchers ask:

R: "How did you do to solve the problem?"
S: "The equation asked how many years if the population reaches 300, so I immediately solve it using the logarithmic formula. So the population plus the population multiplied by the growth rate is equal to three hundred. Then, since there is the same factor of multiplication, and because of the power of n, by logarithm I get 16, 4 but I rounded it to 16 years.

From the answer, the student has been able to interpret the problem into a mathematical form, such as writing the problem into the form of logarithm that is $a.b^n = x$, and orally as seen in the above interview.

Q2

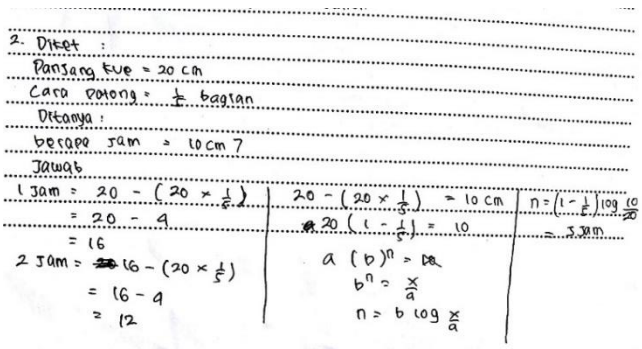

Figure 4. second part of student's answer for Q2

In question number 2, the student has also been able to understand, interpret both orally, and in writing, or in another visual form. This is seen in student assignment which is student was able to understand by writing what was known and asked and his answer is correct. It's also seen when researchers interviewed the student, and the student can explain it. Researchers ask:

R: "How did you do to solve the problem?"
S: "We know that the length of the cake is 20 cm, we cut it on 1/5 parts. The question asked how many hours for the cake to become 10 cm long. Well, at first I initially I count one by one but because I am lazy, I immediately solve it using the pattern. So the length of the cake is reduced by the length of the cake multiplied by 1/5 which is to equals 10 cm. By using factorizing, I continue to use the pattern, and I got that's n is equals to 3 hours.

From his answer, the student has been able to interpret the problem into a mathematical form, such as writing the problem into the form of logarithm that is $a.b^n = x$, and orally seen as in the above interview.

3. **Ability to demonstrate and describe through oral and written**

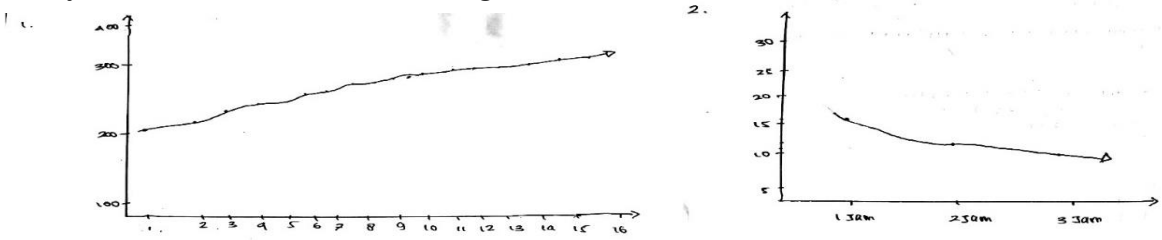

Figure. 5 graphs made by the student for Q1 (a) and Q2 (b)

The student has been able to demonstrate and illustrate in written. This is seen in the graphs made by the student for answer numbers 1&2. The student can draw a graph of upward function for question number 1 which means the number of population increases each years and decreases for problem number 2 because the brownies length will be reduced on each cuts. The student can explain orally as shown in interview below:

R: "Do you understand the graphics you made?"
S: "Yes. The graph on number 1 goes up, and on number 2 it goes down. So going up it means the base a is big, and if it goes down it's small.

Based on all the results it can be explained that student have been able to use mathematical communication skills well and meet the three indicators according to NCTM [1], although there is little error in writing, but in orally the student can already explain it. So, it can be said that the student has been able to use his communication skills both orally and in writing. The research by Fachrurazi conclude that there is an increase in mathematical communication, students who learn to use PBL model. Students using PBL experience improved mathematical communication than students using conventional learning [8]. Meanwhile, according to Hastuti the application of PBL can improve the communication skills of students of class VII. The improvement of mathematical communication ability can be seen from the percentage of improvement of the indicators. This means the PBL model works to improve students' mathematical communication [9].

CONCLUSION

The student has meet the three indicators of mathematical communication skills both orally and in writing although there is still a little mistake in writing.

ACKNOWLEGMENTS

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