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Students' understanding of logarithms using the growth of *Euglena viridis* context

Students' understanding of logarithms using the growth of *Euglena viridis* context

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Abstract. This study aimed to produced learning trajectory with the growth of *Euglena viridis* context that can help students understand about logarithm. Subject of the research were students X SMA N 1 Tanjung Raja, South Sumatera, Indonesia. The method used was design research with three stages, those are preparing for the experiment, the design experiments, and the retrospective analysis. Data collection conducted through video recordings and photos to see the learning process in the classroom, written tests, observation and interviews during the learning process with the students that is the subject of research. Learning trajectory was designed from informal stage to the formal stage. At the informal stage, the contextual problem used as a starting point to explore the students' knowledge of logarithm. The results showed that the use of the graph of *Euglena viridis*' growth can be a bridge of students thinking and help students in understanding about logarithm and product properties of logarithm.

1. Introduction

Based on the curriculum 2013, one of the mathematics subject material in senior high school is about logarithmic equation. Logarithmic material is included in the subjects mathematics which is studied by students of class X. This material important for student to learn. The exponential and logarithmic functions are important concepts that play a fundamental role in mathematical material, including calculus, differential equations, and complex analysis[1].

In the fact, students faced many difficulties in understanding and solving the problems related to logarithms. It is known from several studies, that many students think logarithms are meaningless and include unintelligible rules [2]. Students have difficulty in understanding the concept of logarithms as an inverse of the exponential form and properties of logarithms so that it can not apply it in the matter of question [3]. In addition, the difficulties faced by students is on understanding the complex forms of logarithmic and other problems related to logarithms [4].

One of the factors which is inhibiting students to understand the logarithmic materials are interest and motivation of students, and the ability of the teachers in delivering the material [5]. Furthermore, teachers still use the traditional teaching methods whereby the teacher as the center of learning and teaching materials of logarithmic properties taught through lecture methods [6]. The inhibiting factors of students in understanding logarithms is the use of realistic context to help students' understanding is rarely found in logarithmic units [7].

In every opportunities, mathematical learning should be started with the introduction which is appropriate with contextual problems. The use of real problems in learning can enable students to participate actively in learning so that students are motivated to increase their interest in learning [8]. Indonesian Realistic Mathematics Education (PMRI) is a learning approach that allows for the linkage between context and learning so that meaningful learning can be achieved. This is due to the fact that in the PMRI, realistic or contextual problems are used as a first step to build a mathematical concept [9], [10], [11], and [12].

The philosophy of Realistic Mathematics Education, context should be used to construct mathematical concepts. This process is called conceptual mathematical [13]. The exponential "growth" context along with the graphs is the key for students to understanding logarithm. The Research which is related to the use of realistic mathematics on logarithmic materials is [7]. Students did not have a scheme to understand logarithms, but after two week experiment of implementing realistic mathematics on logarithmic materials, indicated that students could gain an in-depth understanding of the relationship between exponential growth and logarithms [7].

From the results of previous studies that use realistic mathematics education approach, suggesting that the realistic mathematics education has a very good role to be applied in the material of logarithm. One application of the logarithm that can be used is in growth of *Euglena viridis*. Generally students Grade 10 already know one example of the protist is *Euglena viridis*. It is because grouping the protists based on the characteristics, the way of reproduction, and linking their role in life is the basic competence that should be studied by the students of grade 10 on Biology subject. The special features *Euglena viridis* that multiply by splitting themselves into two new individuals with the same parent, can be used as starting point in learning.

From the discussion above, researcher aims to generate the learning trajectory of students in learning logarithm using context the growth of *Euglena viridis*.

2. Methods

This research used a design research approach, which is an appropriate way to answer research items and achieve the research objectives that started from prepare for experiment and preliminary design, design experiments, and retrospective analysis [4]. Design research aim to develop Hypothetical Learning Trajectory (HLT) and also develop Local Instruction Theory (LIT) with the cooperation between researcher and teacher to improve the quality of learning [15] &[16].

After studied the literature, researcher formulated a Hypothetical Learning Trajectory (HLT) consisting of three components: (a) learning objectives, (b) planning learning activities (made the lesson plan, teacher's guide, activity sheets), (c) Made conjecture or hypothesis (conjecture of student thinking). That conjecture was about the process of learning where teacher and researcher can anticipate the development of mathematics collectively and how the development of students' understanding, because learning activities in the classroom based on the design of learning that has been designed [17]&[18].

The data collection in this research is done through several activities such as observation, interview, pretest, documentation (documentation data collected through scan result of student activity sheet, photos and video recording during learning process in class) and post-test. The technique of data analysis of this research will be conducted qualitatively. The analysis will be done is to compare the results of observations during the learning process with the predicted learning trajectory which has been designed in the preliminary design. The analysis done at the preliminary design is the analysis of observation result and the result of interview with the teacher [19]. Further, data on the pilot step and teaching experiments such as students' activity sheets, video recordings, photographs/documentation, and field notes were analyzed to answer the research problem formulation and compared with the designed HLT.

3. Result and Discussion

Based on data analysis, the results showed that learning trajectory of logarithm using context the growth of *Euglena viridis* can help students understand about logarithm form and the product properties of properties logarithm.

3.1. Stage 1 Result : Preliminary Design/Preparing of Experiment

The researcher made literature studies on the material in the 2013 curriculum, the logarithmic materials, the appropriate learning approach, the context that can be used, the information between the context and the material, and the research methods that are of a nature. After that, researchers discussed with surgery lecturer Dr. Somakim, M.Pd. and Dr. Hapizah, M.T. about the instruments to be used in the preparation of the research. From the discussion, the HLT design, Student Activity Sheet (SAS), test questions, Learning Implementation Plan (LIP), Teacher's Handbook and guidelines were obtained.

Result of this study in the stage 1, the researcher conducted a literature review on the curriculum 2013 in Indonesia, the research material which is important to be studied by students is logarithm, as well as the difficulties, circumstances, constraints and inhibiting factors experienced by students along learning about the material. The researcher also conducted a literature study about the learning method which is supposed to give positive result for the students, through the learning of mathematics realistic education.

Furthermore, the researcher designed the prediction of student learning path consisting of three components namely, learning objectives, mathematical ideas, and learning activities. It is intended teacher and researcher can anticipate the development of students' understanding and used direct the learning activities in the classroom based on the HLT that has been designed. At this stage, the researchers designed the Hypothetical Learning Trajectory (HLT) on the logarithm by using context the growth of *Euglena viridis*. The growth's graph of *Euglena viridis* was a starting point in learning logarithm form and product properties of logarithm.

From the HLT, two activities were generated, ie activity 1 was aimed to find the form of logarithm by observe and compare the graph and exponential functions, activity 2 was aimed to find product properties of logarithm by observe and compare the graph and logarithm form.

3.2. Stage 2 Result : The Design Experiment

In this stage, there are two cycles. Cycle 1 known as Pilot Experiment and the cycle 2 known as the Teaching Experiment. In cycle 1, learning design and HLT that have been made at the preliminary design stage were tested to 6 non subject students. This step aims to determine whether the HLT has been designed to have high difficulty, moderate or low. This is intended to determine the suitability of HLT with actual learning. The six students are from IPA 2 class X consisting of two high-ability, two medium-skilled, and two low-skilled.

The teaching experiment was held in class X IPA 4 SMA Negeri 1 Tanjung Raja which amounted to 32 students. Mrs. Rusmaini, S.Pd. as a classroom teacher becomes a model teacher at this stage. In the implementation of learning, teachers divide students into 6 groups consisting of 5-6 students. Each group consists of high, medium and low-ability students. At this stage the researcher serves as an observer who sees the student's strategy in solving the given problem.

The HLT used at this stage is the result of a revision of the pilot experiment stage. The learning process begins with the giving of pretest, two meetings on learning activities and then followed by giving post-test. Before the teacher distributes the students to the group, the teacher first gives pretest questions to the students. It is intended to know the initial knowledge that students have about logarithmic material. In the preliminary activities, the teacher greets and opens the lesson, checks the preparedness of the class, performs the a perception by asking questions about the exponent form to

know the initial knowledge of the students. The teacher asks one of the students to write an example of an exponent form.

Teacher told about the link between the material that will be studied with the material in Biology lesson is about the types of protist and the way of breeding. Teacher told about the purpose of learning that is about the material logarithm and its relation to the protist example that has been mentioned students. The teacher then reads the group names and asks the students to sit down with their group. Then the teacher distributes activity sheets (SAS) for each student. The teacher also instructed that there was a group activity sheet to be collected at the end of the lesson. The teacher gives a few minutes for each student to read the activity sheet first before discussing with the group members.

In the first activity on SAS 1 is shown graph of the growth process of *Euglena viridis* in a pond. Students are asked to observe and interpret the graph. Each question on activity leads the student to know that *Euglena viridis* splits into twice daily, so that 2 is a growth factor. Then the student determines the function according to the graph, that is exponential function with the base number 2. The graph is as follows

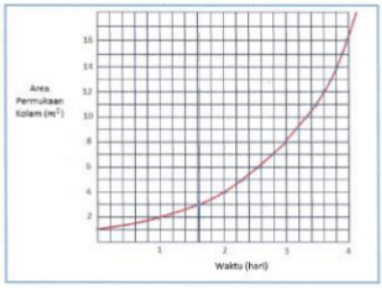

Figure 1. Contextual problem the growth graph of *Euglena viridis*

Once the student is able to determine the appropriate function with the graph, the student is asked to determine the area that is formed on the 4th, 5th and 6th days. By using the function that has been made before the student can determine the time. Furthermore, the logarithmic form is introduced as the time required for Euglena to form 16, 32, and 64 square meters. The student explained the meaning of the log form. The image below shows the student's answer.

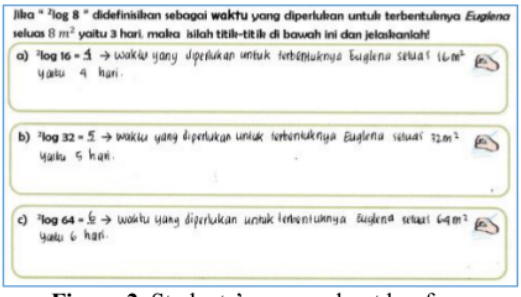

Figure 2. Students' answer about log form

Then on the activity 2, students compared the forms of exponential functions and logs on activity 1. Students can make conclusions in their own opinion. Students can link between the exponent and the log form. There were students who can get the link and some were not. The following is the student's answer that can turn between exponents and logs and students who have not been able to associate them.

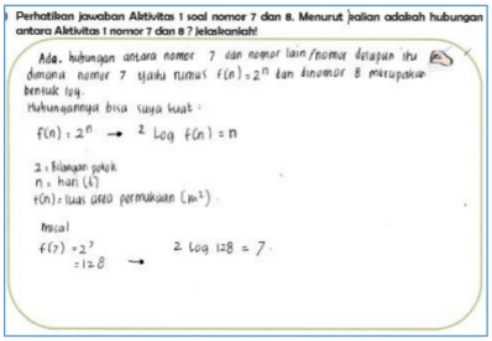

Figure 3. Students' answer about link between exponent and log form

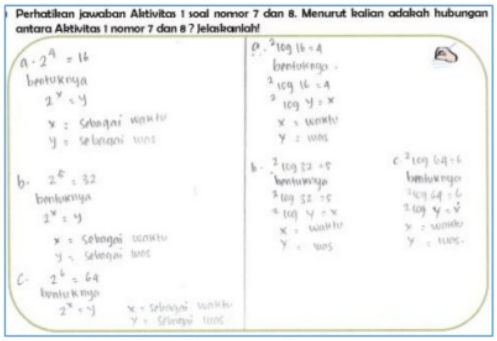

Figure 4. Students' answer about exponent and log form

The students were asked to draw a graph from the log function and compare it with the previous exponential function graph form. Students can conclude that the graph of log and exponential functions are opposite. Indirectly the student knows that the log function is the inverse of the exponential function. On activity 3 there is already a more formal logarithmic problem.

SAS 2 still displays graphs as in SAS 1. In Activity 1, students must explain the meaning of the logarithmic form by using the graph. Then the students get the conclusion that the value of 2 log 2 is equal to 1. In activity 2, students analyze the three logarithmic equations contained in the previous activity. Students can compare and analyze it. Student answers can be seen in figures 5 and 6.

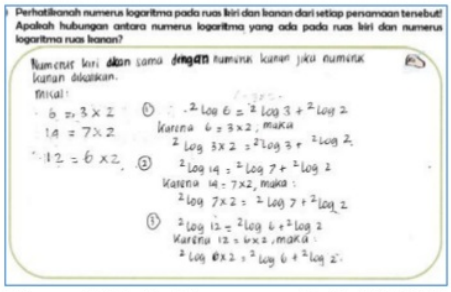

Figure 5. Students' answer activity 2 SAS 2

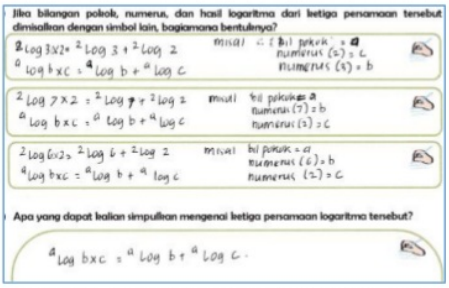

Figure 6. Students' answer activity 2 SAS 2

In the end of activity 2 students can make a conclusion about the form of the three logarithmic equations. In activity 3, there is already a problem of the more formal logarithmic multiplication properties.

3.3. Stage 3 Result : Retrospective Analysis

Activity 1 (SAS 1) aims to know and understand logarithmic form through the context of the growth of *Euglena viridis*. Students work according to predictable conjectures. Various answers arise in solving the given problem. From this activity it can be concluded that students can understand that the exponential shape can be converted to a logarithmic form. Various answers and student strategies that appear in accordance with the conjecture that has been made.

The second activity learning (SAS 2) objective is to identify the properties of logarithmic multiplication through the context of *Euglena viridis* proliferation. Students work according to predictable conjectures. Various answers arise in solving the given problem. From this activity can be

concluded that, students can understand and solve problems related to the nature of logarithmic multiplication through the use of context of *Euglena viridis* proliferation.

Post-test is implemented after the teaching experiment stage has been completed. In this post-test, 30 students worked on the problem individually for about 15 minutes. This post-test aims to see how far students understand the material of logarithmic form and the use of logarithmic multiplication properties in problem solving. The type of problem given in this post-test is the same as the pretest that was done at the beginning of the lesson.

Based on the HLT that has been designed and implemented before, there are two logarithmic learning activities at the pilot experiment stage and the teaching experiment stage. Activities in this cycle include activity 1 ie students identifying the form of logarithm through the context of *Euglena viridis* proliferation; and activity 2 that students identify the nature of logarithmic multiplication through the context of *Euglena viridis* proliferation. The proliferation context of *Euglena viridis* provided in this study into a starting point in mathematics learning showed good results for students.

The first activity shows students about the form of logarithms through graphs on the proliferation of *Euglena viridis*. The first issue is the introduction of the virulent *Euglena viridis* breeding context by asking students to pay attention and interpret it from the graph. Furthermore, students are asked to determine the function according to the graph. After being able to find the appropriate graph, the student knows that the corresponding graph is an exponential graph with two principal numbers.

Furthermore, students are asked to determine the time so that *Euglena viridis* can reach a certain area by way of re-reading the graph. Then the students are asked to determine the time in which the area is not on the graph. The student uses his reasoning and the initial idea that *Euglena viridis* always doubled every day. Once the student can determine the time, then the time is interpreted in another form. At that mome the logarithmic form is introduced as the time required by *Euglena viridis* to reach a certain area. At the end of the activity, students are asked to make a conclusion from beginning to end. Teacher plays a important role at this stage. Groups that have difficulty directed and guided by teachers to achieve the purpose of learning is to identify the form of logarithms.

The second activity is still related to the first activity of the proliferation of *Euglena viridis*. Students re-read and interpret the graph. Students are asked to explain some m of logarithm. there are three similar questions so that students can get an idea of the conclusions of the form. The students are then asked to draw conclusions from the previous three examples. At this stage the teacher plays a role in directing students to the nature of logarithmic multiplication. After that, students are asked to prove the nature of the logarithmic multiplication. At this stage the teacher also has a role in directing students. It is intended that students do not necessarily get the formula or the logarithmic multiplication properties of printed books or textbooks of mathematics. Students can know that the formula is a logarithmic and can be proven mathematically. This activity makes students more enthusiastic than giving the formula directly.

The use of exponential growth graph has also been done by [13] and [7]. In the study, the exponential growth graph along with the context can help students understand about logarithms. After conducting a teaching experiment based on HLT. There was a learning trajectory (LT) of logarithmic material using the context of the proliferation of *Euglena viridis*. The learning trajectory can be seen in Figure 7 and 8.

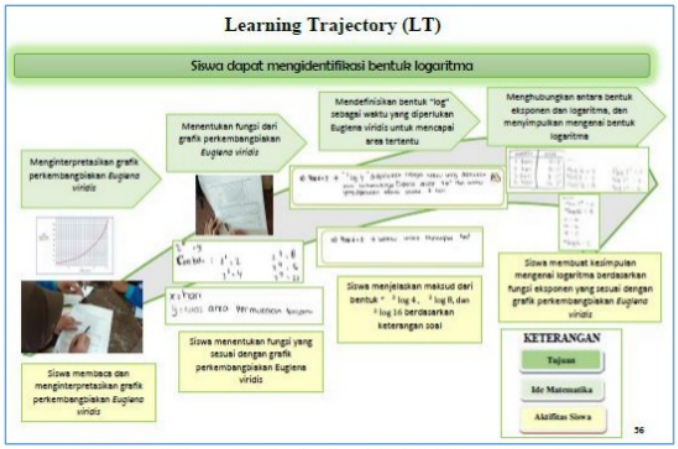

Figure 7. Learning trajectory (LT) of logarithm form

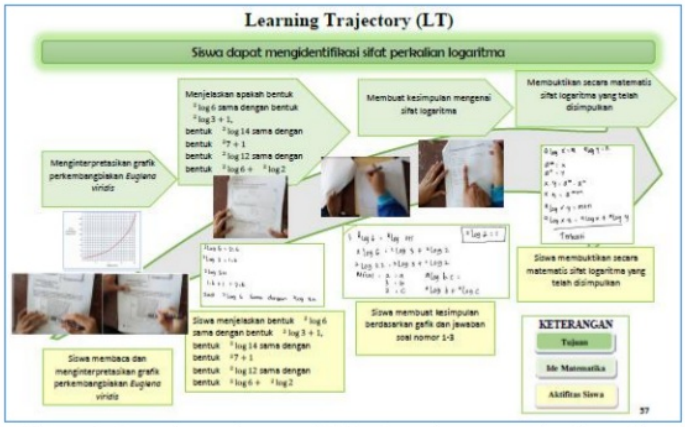

Figure 8. Learning trajectory (LT) of product properties logarithm

4. Conclusion

Based on the design of learning trajectories that have been designed and implemented before, there are two logarithmic learning activities at the pilot experiment stage and the teaching experiment stage. A series of activities in this cycle include activity 1 that is students identifying the form of logarithm through the context of the growth of *Euglena viridis*; and activity 2 that students identify the properties of logarithmic multiplication through the context of the growth of *Euglena viridis*. The context of growth of *Euglena viridis* provided in this study into a starting point in mathematics learning shows good results for students.

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