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Analysis of the Impact of Android Applications-based Mathematics Learning on Increasing Students' Mathematical Representation Skills

Ricki Yuliardi [1,2], Dadang Juandi [1], dan Syafdi Maizora [1,3], Asep Mahpudin [4]

[1] Departemen Pendidikan Matematika UPI Bandung, Indonesia

[2] Program Studi Pendidikan Matematika STKIP Muhammadiyah Kuningan, Indonesia

[3] Program Studi Pendidikan Matematika Universitas Bengkulu, Indonesia

[4] Program Studi PTIK, STKIP Muhammadiyah Kuningan, Indonesia

Corresponding Author: rickisyahidan27@upi.edu [1], dadang.juandi@upi.edu , syafdiichiemaizora@upi.edu , asepmahpudin@upmk.ac.id

History Article

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Abstract

This research is motivated by the low mathematical representation skills of students. Mathematics learning based on android applications is an alternative idea that can be a solution to the problems above. The results showed: (1) Mathematics learning based on android applications has a positive impact on the ability of students' mathematical representation (2) from the results of the analysis of students' answers, it is concluded that students' representation skills in solving various questions, diverse representations are a manifestation of the solution strategy In addition, there are several learning barriers, including misinterpretation of the application of concepts, the fluency of students in connecting between concepts and other mathematical concepts, as well as student difficulties in communicating mathematical ideas, (3) The solution that can be done is the use of technology that can improve skills. students 'mathematics and (4) the need for a teacher to compile HLT as a basis for students' thought processes in learning the concepts of roots, ranks and logarithms.

Abstrak

Penelitian ini dilatarbelakangi oleh masih rendahnya keterampilan representasi matematis siswa. Pembelajaran matematika berbasis aplikasi android adalah salah satu gagasan alternatif yang dapat menjadi solusi permasalahan diatas. Hasil penelitian menunjukan: (1) Pembelajaran matematika berbasis aplikasi android memiliki dampak yang positif terhadap kemampuan representasi matematis siswa (2) dari hasil analisis jawaban siswa, didapatkan kesimpulan bahwa keterampilan representasi siswa dalam menyelesaikan soal beragam, representasi yang beragam merupakan perwujudan dari strategi penyelesaian yang berbeda, disamping itu ditemukan beberapa hambatan belajar diantaranya kesalahan interpretasi penerapan konsep, kelancaran siswa dalam menghubungkan anatra suatu konsep dan konsep matematika lainnya, serta kesulitan siswa dalam mengkomunikasin ide gagasan matematis,(3) Adapun solusi yang dapat dilakukan adalah pemanfaatan teknologi yang dapat meningkatkan keterampilan matematis siswa serta (4) perlunya seorang guru menyusun HLT sebagai landasan proses berpikir siswa dalam mempelajari konsep akar, pangkat dan logaritma.

Keywords: Mathematical Representation, Android Based Learning, Covid19.

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BACKGROUNDS

The presence of the COVID-19 Pandemic as a global pandemic has had a tremendous impact on mankind. The massive spread of the virus through interactions between humans suddenly changed the pattern of human interaction in socializing, as well as this has an impact on the world of education (Ahmed et al., 2020). Minister of Research and Technology, Bambang Brodjonegoro, conveyed that indirectly the Covid19 pandemic forced us to accelerate into the Fourth Industrial Revolution faster (Press Conference, 2020). In practice, current conditions require educators and students to be able to transfer knowledge online. Online learning can take advantage of platforms in the form of applications, websites, social networks, and learning management systems (Gunawan et al., 2020).

Mathematics is one of the branches of science that has a significant contribution to the development of technology and human civilization, many applications of mathematical concepts are the basis for the development of science and technology today (Nurjanah et al., 2020). Learning mathematics is not just conveying information, showing formulas, and emphasizing procedures for processing questions. However, the teacher acts as a facilitator whose task is to help students create conducive learning so that students actively and continuously construct their own knowledge. Mathematics learning also trains students' skills to solve problems, where problem solving skill is one of the skills needed in the 21st century (Erdogan, 2019).

Mathematical Representation Skills

Neria & Amit (2004) stated that student success in problem solving is highly dependent on student's skills in representing a problem, such as constructing principles, propositions, theorems and using mathematical representations in the form of graphs, notations, equations, tables and figures or manipulation of other mathematical symbols. NCTM (National Council of Teacher Mathematics, 2000) and Sumarmo (2010) stated that representation is an expression of mathematical ideas used by students in the form of mathematical notations, graphs and symbols as an effort to find solutions to problems that arise as a result of the interpretation of their thoughts.

Minarni et al., (2016) explained that mathematical representations can be expressed in the form of visual and non-visual interpretation. Visual representations including graphs, tables, sketches/figures, and diagrams; non-visual representations including numerical representations, and mathematical equations or mathematical models. Based on Fitrianna et al., (2018), five indicators of mathematical representation ability include; 1) use visual representation to solve problems; 2) use data/information from a representation into diagrams, graphs, or tables and solve problems using mathematical words or notation; 3) develop mathematical equations or models in solving problems involving mathematical expressions 4) draw geometric patterns, write down mathematical problem solving steps and solve problems with mathematical expressions; and 5) create problem situations based on the data or representations provided.

However, student's mathematical representation ability in building mathematical understanding is still very limited. Based on the results of Trends in International Mathematics and Science Study (TIMSS) 2015, Indonesia only scored 397 and placed Indonesia in 44th place out of 49 countries (Mullis et al., 2015). Meanwhile, based on the results of Program for International Student Assessment

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(PISA) in 2012, Indonesia ranked 64 out of 65 countries in the ranking of mathematical intelligence with an average score of 375 (Schleicher, 2014), then in PISA 2015 and 2018, the average mathematical intelligence scores in Indonesia were 386 and 379, respectively (Schleicher, 2019).

One of the causes of Indonesian students' low mathematics learning achievement was that because Indonesian students still rare in finding and solving problems that develop mathematical representations. Therefore, that new learning innovations are needed that integrate technology as the key to face the era of the industrial revolution 4.0 and human society 5.0, allowed to be accessible by students flexibly wherever and whenever (Lane, 2016).

Based on a previous study conducted by a researcher at several schools in Kuningan Regency in 2019, it was found that most students had difficulty in representing mathematical symbols, graphs, notation, and converting daily problem solutions into mathematical models and it required considerable attention for the educators / researchers (Mahpudin et al., 2020).

Android-based Mathematics Learning

One of the efforts that can be done to develop students' mathematical representation ability and encourage students' interest is to choose an appropriate IT (Information Technology) / ICT (Information Communication Technology) assisted learning model so as to be able to develop students' mathematical representation ability to the maximum and learning will be more meaningful (Mahpudin et al., 2020). Lately, smartphones have been widely used as important devices to support various aspects of human life. Smartphones that allowed humans to communicate without being hindered by space and time, technological advances have changed the e-Learning and mobile learning systems (Kularbphettong et al., 2015).

Learning using smartphones is a technology developed to support students and teachers through the internet using electronic devices. (Laouris & Laouri, 2008) explained that the change from e-Learning to mobile-learning shows that the revolution has not changed in terminology but also in the mindset of the learning environment. Mobile-based learning opened the learning boundaries to support learners to learn anytime, anywhere, with ease.

Relevant preliminary research studies include: (Kularbphettong et al., 2015; Laouris & Laouri, 2008; Ma et al., 2014; Nuraeni et al., 2020) whose research conclusions are that smartphone-based learning can be an effective learning alternative for students and teachers in improving students' learning achievement and has interesting development prospects for further studies. However, there are not many studies that examine further about the analysis of the impact of android-based learning on mathematical representation ability. Therefore, based on the above considerations, we are very interested in developing android-based learning media to optimize students' mathematical representation skills. This article aims to find out : (1) How are the implementations of Android-based mathematics learning (2) How are the processes of students' mathematical representation in the implementation of Android-based mathematics learning. (3) How to anticipate learning that must be perfected to optimize students' representation skills.

Table 1. Stages of Android Applications-assisted Mathematics Learning

Apperception Phase
1. The teacher conditioned students to learn
2. Students prepared learning resources, including Android phones that have the application installed
3. The teacher conveyed learning objectives
4. The teacher did an apperception about the subject matter to be studied, namely indices, surds, and logarithms
Exploration and Elaboration Phase
1. The teacher explained the basic concepts of indices, surds, and logarithms
2. Students explored Android application
3. Students did the procedural exercises, where in the application, small boxes are provided for filled in students' answers
4. For those who answered correctly, there will be an explanation and if there was an error, feedback will appeared
5. Students conducted group discussions using the chat feature
6. The teacher provided guidance when students have difficulty
7. Students were given the opportunity to presented the results of the discussion
Confirmation and Closing Phase
The teacher directed and provided opportunities for students to drew conclusions about a concept or procedure related to the contextual problem being solved.

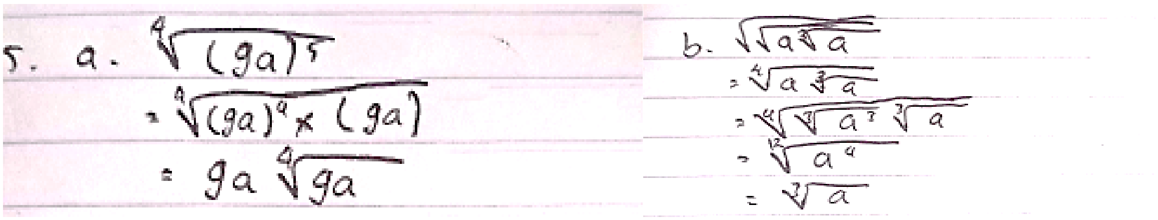

Figure 2. Result of Student's Answer about the Representation of Surds Form

METHODOLOGY

The approach used in this study is a qualitative research approach with the objectives that are provided an overview of the steps of android applications-based learning and revealed the problems faced by students when thinking about representation in solving problems of indices, surds, and logarithms. The subjects of this study were 10th grader students of SMA Muhammadiyah Yogyakarta class X MIPA 3 with the number of students that were 20 with 4 members in each group so that 5 groups were formed. The research data were obtained through observations of student learning activities in the classroom as well as interactive activities between students and the android application used. Besides that, data were obtained from students' test results in working on questions of indices, surds, and logarithms and interviews with the teacher who supervised the lesson as well as interviews with students about the difficulties (especially when using mathematical representations) students faced in solving problems of indices, surds, and logarithms. The limitations of this research are that the application made is the second version development and is only made to explain the concepts of indices, surds, and logarithms, and the scope of the research carried out only covers Kuningan Regency and Yogyakarta City.

RESULTS AND DISCUSSIONS

Learning Implementation Results

The learning implementation was carried out during November-December 2020. The learning method used was software-assisted mathematics learning with the Android-based Mathematics Equation Editor application. Previously, in the preparation stage, teachers and students had downloaded the application through Google Playstore for free. The stages of android applications-assisted mathematics learning in detail are presented in Table 1.

The Android Equation Editor application is a learning media development project that was developed for two years, where in the first year of its development, this application could display several mathematical symbols according to the needs in the field. The user would interact with the application through the user interface provided by the application. The user will be presented with a button consisted of the necessary mathematical symbols such as fractional, ex-

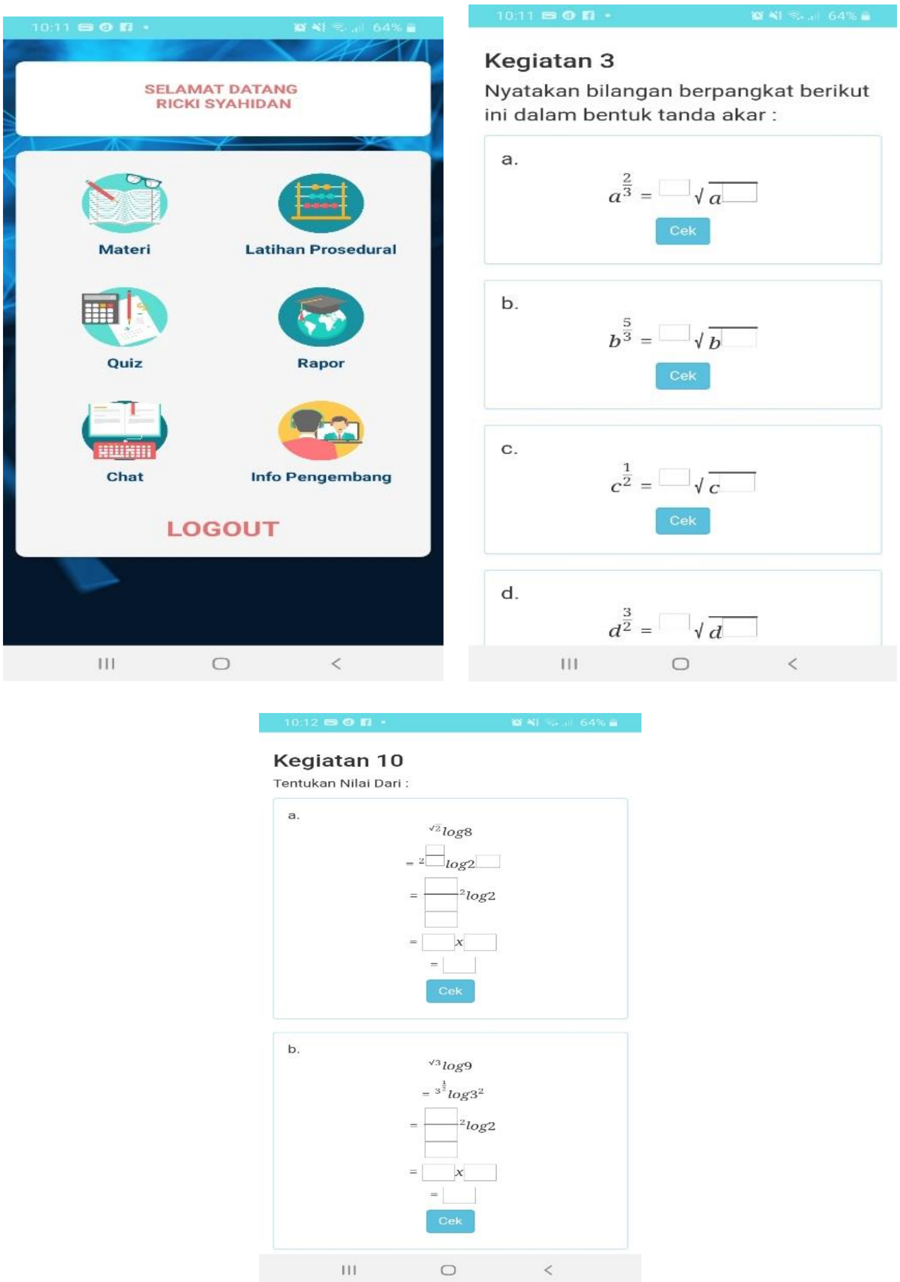

Figure 1. Android Application Interface

ponential, radical and logarithmic functions. While in the second year (second version) there were several improvements and additional features, including: Application features to do the indices, surds, and logarithms procedurally, Practice / Quiz and chat features where students could discuss problems related to indices, surds, and logarithms. The following is an enhanced view of the mathematical equation editor program (second version) shown by the Figure 1.This application aimed to provide an understanding of mathematical expressions related to indices, surds, and logarithms, to did the representation of the properties of indices, surds, and logarithms, and to trained students to do the problems systematically and procedurally. With this application, it was hoped that it could help students' difficulties, namely: difficulty in interpreting mathematical symbols and expressions, difficulty in applying the properties of indices, surds, and logarithms, and difficulty in explaining procedure steps in solving problems. Based on the results of field tests, the results of average achievement of each indicator of mathematical representation (which have been adapted according to surds, indices, and logarithms subject matter) were obtained and shown in the Table 2.

Based on the results of the significance test of the effectiveness of the Android-based mathematical equation editor application which was developed using student response questionnaires. The results of the analysis of the initial test score obtained a mean score of 5,53 and the final test obtained a mean score of 19,11, the n-gain test score obtained a mean of 0,554 with moderate improvement criteria. This showed that students experienced an increase in their mathematical representation ability from the initial test to the final test. Meanwhile, based on the results of the questionnaire on student responses to Android application-assisted learning, students gave a positive response of 83%.

Discussions

After students did the posttest which consisted of 10 description questions, the results of students' work were analyzed, to examined students' thinking processes and obstacles that may occur in learning. The results of students' answers were shown in the Figure 2.

The problem above is a surds problem, there are several steps that could be taken to solve this problem, but where the phenomenon that were often found were that students are able to change the form of surds to a simpler one, by first breaking $(9a)^5 = 9a^4 \times 9a$ to be able to

Table 2. Analysis of achievements of mathematical representation indicator level

	Representation Ability Indicator	Average Achievement
1.	Provide data or information from a representation of a diagrams, graphs, or tables related to the indices, surds, and logarithm subject matter	78 %
2.	Apply the principles contained in the indices, surds, and logarithm subject matter and solve problems involving mathematical expressions procedurally	68%
3.	Look for the representational relationships between one procedure and another or between mathematical topics and create mathematical equations or models from the representations given in solve problems of indices, surds, and logarithm	62 %
4.	Construct problem situations based on the data or representations provided, write interpretations and steps for solving mathematical problems and be able to communicate them both orally and in writing	44 %

extracted from the 4^{th} root, at this stage students were able to understand the basic concept of surds, although the value of $9a$ in the roots could still be simplified to $9a \times 9a \times \sqrt[4]{9a} = 9a \times \sqrt[4]{9a}$ here the process has not stopped because what was requested was to convert into indices so that the final result was $9a \times 9a^{\frac{1}{4}} = 9a^{1+\frac{1}{4}} = 9a^{\frac{5}{4}}$

As for question 5b, almost the majority of students (77%) answered incorrectly, and the rest answered correctly but could not explain the steps clearly. As for mathematically to find the results of this question through the implementation of the properties of indices and surds, as shown by the algebraic procedure below:

$$\sqrt{\sqrt{a\sqrt[3]{a}}} = \left(\left(a^{3/3}a^{1/3}\right)^{1/2}\right)^{1/2} =$$

$$\left(\left(a^{4/3}\right)^{1/2}\right)^{1/2} = a^{4/12} = a^{1/3}$$

Then the next question was about the application of the indices concept in the implementation of daily problems with the problem-solving question type, while the question tested was shown **on Figure 3**.

For the question above, students could use several alternative ways of solving, firstly by making a table, students determined the number of bacteria by looking at the pattern of bacterial growth every hour. However, solving answers with tables is not effective for more hours. In contrast, the second alternative is the implementation of the indices principle, which is integrated with the concept of sequences and series, in the answers above, student has shown an idea by creating problem situations based on the questions given, student has been

Question 7
Researchers at a research institute were observed the growth of a bacterium presented in a type of fungi in a microbiology laboratory. When observed using a microscope, one bacterium could divide into r bacteria per hour. The results of observations at the end of the first 3 hours, the number of bacteria reached 10,000 bacteria and after being examined again 2 hours later, the number of bacteria became 40,000 bacteria. The researchers wanted to know the number of bacteria as a result of division and found out the number of bacteria in 8 hours. From the information above, determine the number of bacteria after 8 hours?

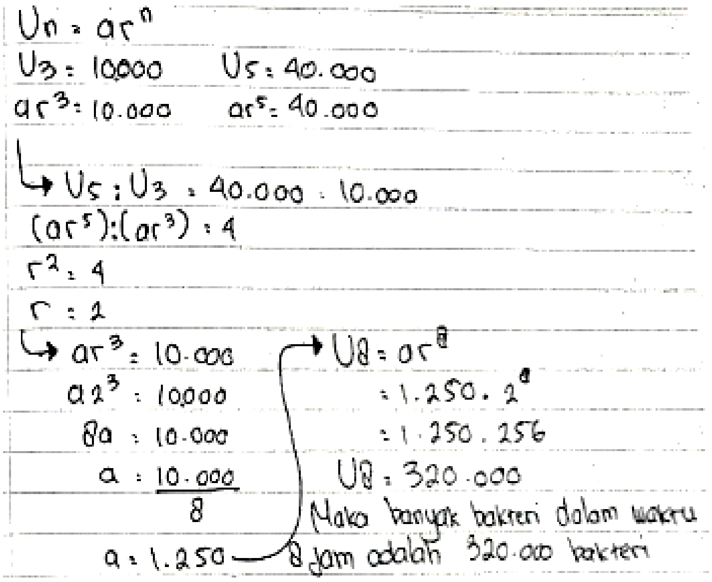

Figure 3. Questions and Results of Student's Answers about the Concept of Indices

able to interpret to solve the problem, what needs to be looked for is the ratio (comparison of the n^{th} term with the previous term), the student then compared the 5^{th} term and the 3^{rd} term by using the ratio of the number of bacteria at the end of the first 3 hours and the end of the 2 hours after that, namely the 5^{th} hour in this case student made conjectures from a number pattern. After the ratio is known, which is 2, meaning that the bacteria divided into 2 every time unit (hours), after the ratio is found, the next step is to look for the first term. The first term is obtained by substituting the variable r (ratio) in the term for which there was an answer, after found the first term, student then determined the eighth term by using the parameter values that have been obtained previously, then it was obtained the result was 320.000 bacteria. The thing to note was that students already had to understand the meaning of the notations. An understanding of the meaning of the notations was necessary as a first step for students to find a problem-solving solution design (Utami et al., 2018). The next step was students to understand how to interpret the use of sequence and series formulas by using indices, surds, and logarithmic skills to solve problems involving mathematical expressions.

In solving the problems above, students tried to first wrote down the formula that will be used, then students wrote down the interpretation of the problem to be solved, then students wrote down the steps for solving math problems in words, for example M as initial savings, Mn as final savings , i is the amount of interest (in %) per year and n is the period of savings, the question was slightly different from the usual problem here, students must first analyzed the available variables, then students must be able to related the concept of bank interest to the concept of surds, indices, and logarithms to create a mathematical model that was the equation:

Question 8

Yusuf is a 10^{th} grade student in Yogyakarta City. He dreams of going to college without burdening his parents, so he always saves his money and decides to start saving up his money. In the early stages, he managed to save up to Rp. 1.000.000,00 in a piggy bank. To make his money safer, he saves his money in a bank with an interest rate of 10% per year. How long does Yusuf keep the money so that it becomes Rp 1.464.100?

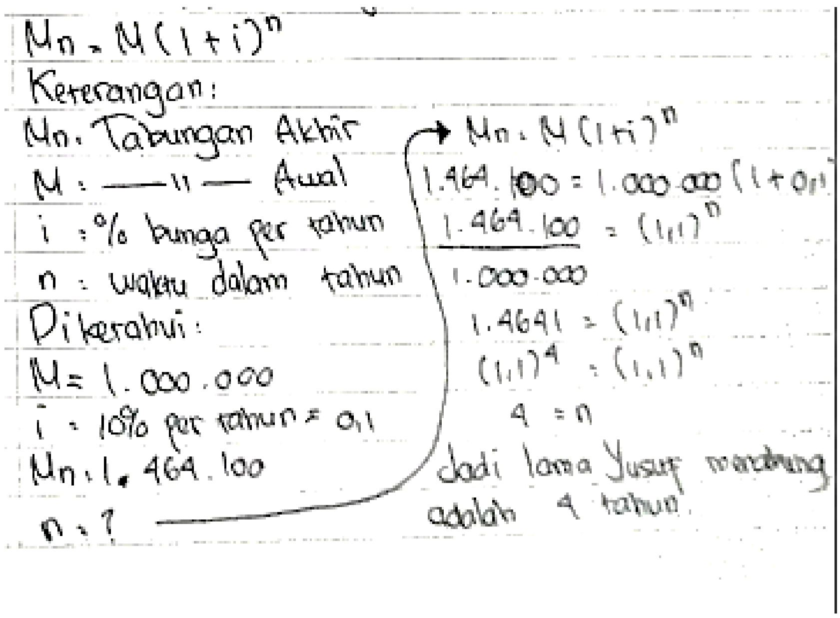
Mn = M(1+i)^n
Keterangan:
Mn : Tabungan Akhir
M : —"— Awal
i : % bunga per tahun
n : waktu dalam tahun
Diketahui:
M = 1.000.000
i = 10% per tahun = 0,1
Mn : 1.464.100
n : ?
Mn = M(1+i)^n
1.464.100 = 1.000.000 (1+0,1)^n
1.464.100 / 1.000.000 = (1,1)^n
1.4641 = (1,1)^n
(1,1)^4 = (1,1)^n
4 = n
Jadi lama Yusuf menabung adalah 4 tahun.

Figure 4. Questions and Results of Student's Answers about the Concept of Logarithms

$$1.464.100 = 1.000.000\,(1+0{,}1)^t$$

where to find t, the principles of indices and logarithms were used. After careful calculations, the answer was that Yusuf must save for 4 years, while the correct solution procedure was shown by the steps below:

$$\log 1.464.100 = \log 1.000.000\,(1+0{,}1)^t$$

$$\log 1.464.100 = \log\,[1.000.000(1{,}1)^t]$$

$$\log 1.464.100 = \log\ 1.000.000 + \log(1{,}1)^t$$

$$\log 1.464.100 - \log\ 1.000.000 = \log(1{,}1)^t$$

$$\log\left(\frac{1.464.100}{1.000.000}\right) = t(log1{,}1)$$

$$\log\left(\frac{11}{10}\right)^4 = t(log1{,}1)$$

$$4log\left(\frac{11}{10}\right) = t(log1{,}1)$$

$$4 = t$$

Based on the results and observations and interviews of students, one of the procedures that were often wrong or considered difficult by students was when changing the form of an equation into a logarithmic form, and students were not yet fluent in carrying out the solving procedure using logarithmic properties. Students were not fluent because they were not used to did the calculations procedurally, in accordance with Arzarello et al., (2012) who said that technology integration in mathematics learning help students' dynamic representation, flexibility and problem solving abilities. This is a very important finding. Therefore, it will become feedback in the design of technology-based media in the future, where the development of this application must be able to stimulate students' flexibility in thinking procedurally and be able to optimize representation skills, especially in problem solving ***

Broadly speaking, the results of this study indicated that students in solving problems were quite good at using mathematical representation skills to produce answers even though the solutions were quite diverse. The diverse representations are the embodiment of the students' solving strategy in solving the given mathematical representation ability test questions.

Based on the results of students' interviews, the use of technology in learning could increase motivation to learn mathematical concepts. In addition, technology-based mathematics learning could improve representational ability shown to organize, record, and communicate mathematical ideas. Students were able to present problems in the form of representations of the concepts of indices, surds, and logarithms. Students were able to choose, apply principles and create mathematical models related to the concepts of surds, indices, and logarithms. Meanwhile, based on the analysis of students' errors at the time of the interview, there were still errors in interpretation and procedures in the implementation of the properties of surds, indices, and logarithms, and students still had difficulty connecting one concept to another mathematical concept such as in the questions of bacterial division and bank interest rates, students already had ideas but still had difficulty writing and communicating the steps for solving mathematical problems in accordance with the command questions.

These were in line with (Minarni et al., 2016; Rahmadian et al., 2019) that students still needed teacher guidance to get to the desired thinking stage and exercise questions that were able to stimulate students' mathematical representation skills are needed. In addition, in line with the research of Nurjanah, et al., (2020), technology-assisted mathematics learning had pretty good potential to improve mathematical skills, one of which were students' mathematical representation and problem solving. The results of research by Marsigit et al., (2020) showed that optimizing representation ability in analyzing cases, presenting data in tables, collaborating among students to solve problems, creating and demonstrating graphic images that utilize technology could support students' thinking in building mathematical concepts. Besides that, there was a need for a teacher to develop HLT (hypothetical learning trajectory) as a learning reference and a guide for students' thinking processes. With HLT, it was easier for teachers to analyze students' thinking errors and anticipate learning barriers that may occur in learning (Fuadiah, 2018; Nuraida & Amam, 2019; Prahmana & Kusumah, 2016; Simon, 2017).

CLOSING

Conclusions

Conclusions: (1) Android applications-based mathematics learning had a positive impact on students' mathematical representation ability (2) from the results of the analysis of students' answers, it was concluded that students' representation skills in solving problems were diverse, diverse representations were the embodiment of different solving strategies, besides that, found several learning barriers including misinterpretation of the implementation of concepts, the fluency of students in connecting one concept and another mathematical concept, as well as students' difficulty in communicating mathematical ideas, (3) The anticipation that could be done where the use of technology that could improve students' mathematical skills and the need for a teacher compiled HLT as the basis for students' thinking process in learning the concepts of surds, indices, and logarithms.

Suggestions

Mathematical representation skills are the most important part in the thinking process and solving mathematical problems, so further studies are needed that will dig deeper into the integration of technology in improving students' mathematical representation skills, in addition, research with the theme of didactic design and studies on HLT will be very suitable to be applied to further examine this topic.

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