Volume 3, Number 2, June 2022
Journal of Research on Mathematics Instruction
DOI: https://doi.org/10.33578/jrmi.v3i2.70
Journal's Webpage: http://jrmi.ejournal.unri.ac.id

Development of Electronic Student Worksheets Based on the Discovery Learning Model to Facilitate Mathematical Understanding Ability of Class XI SMA/MA Students in Limit Function Material

Nur' Aisyah [1], Kartini [2], Titi Solfitri [3]
[1] Universitas Riau, INDONESIA
[2] Universitas Riau, INDONESIA
[3] Universitas Riau, INDONESIA

ARTICLE'S INFORMATION

Article history:

Received: July-21-2022

Reviewed: Oct-03-2022

Accepted: Dec-09-2022

Keywords: Discovery Learning, Limit Function, Understanding Ability, Worksheets

ABSTRACT

This research is motivated by the importance of students' mathematical understanding abilities in Indonesia, especially in Riau Province and the limited number of Student Worksheets that facilitate mathematical understanding abilities. Mathematical understanding is important for students because it becomes a prerequisite for further mathematical concepts, and meaningful learning will last longer. In facilitating students' mathematical understanding skills, meaningful learning is needed. One such learning is the Discovery Learning (DL) model. Applying a learning model alone is not enough to support the realization of an active learning process that can develop students' mathematical understanding abilities. Therefore, a teacher must provide facilities to support students, including developing Student Worksheets. Using appropriate digital technology in learning facilitates and attracts students' interest in learning so that learning becomes more effective. One of the sites that can make student worksheets more interactive by adding media in the form of motion animation, audio and video to it is a live worksheet. This study aimed to produce a product in the form of an electronic student worksheet based on the Discovery Learning (DL) model to facilitate mathematical understanding skills in class XI SMA/MA students on valid and practical Limit Function material. This research uses the ADDIE development model (Analysis, Define, Design, Development, and Evaluation). The resulting product is stated to be very valid and practical with an average percentage validity of 90%, and the average value of the questionnaire response results for students by 83%.

Corresponding address:

Nur' Aisyah,
E-mail: nur.aisyah@student.unri.ac.id

INTRODUCTION

Education is the main component in improving the quality of a nation. For this reason, in recent years, various efforts have been made to increase students' knowledge and understanding of learning, especially mathematics. This is because mathematics is the science that underlies the development of modern technology in advancing human thinking [1]. In line with Hella Apriyanti, mathematics is a basic science that must be mastered to understand other sciences in solving problems of everyday life [2].

One of the mathematical abilities that need to be achieved by students in accordance with the learning objectives in learning mathematics is the ability to understand mathematics. The ability to understand mathematics is one of the main goals in the mathematics education process [3]. This is because understanding a mathematical concept is a prerequisite to studying further mathematical

concepts. In line with that, Heris Hendriana et al. revealed that understanding mathematics is one of the strengths that must be considered during the learning process to obtain meaningful mathematics learning [4]. From the description, it can be seen the importance of mathematical understanding ability in understanding mathematical material.

However, based on survey results, observations and information obtained indicate that students' mathematical understanding in Indonesia is still relatively low. Research conducted found that the average mathematical understanding ability of students in Riau Province is 2.78% which belongs to very low criteria [5]. The indicator restating a concept and classifying objects according to the concept obtained 2.38%. The indicator presenting the concept in various mathematical representations obtained 4.76%. In the indicator of using, utilizing, selecting certain procedures or operations and applying concepts, it is obtained 1.19%. It can be seen that the percentage of all indicators of mathematical understanding used is still very low. Research by [6] showed that students have poor mathematical understanding. Students cannot solve problems using other concepts related to the problem. In line with the research conducted by [1], namely from the mathematical understanding ability test held on the MAN 2 Pekanbaru Model students, only five students (26.31%) achieved the criteria for completeness. This shows that the mathematical understanding ability of high school students in Riau Province is still low.

Based on the results of the national exam (UN) conducted by the Ministry of Education and Culture in 2019, the average UN score for high school students in Indonesia for mathematics subjects was 37.11% [7]. This data shows that students' mathematical understanding skills are still weak in solving math problems. In addition, from observations made on mathematics subject teachers at SMAN 4 Pekanbaru, information was obtained that students had difficulty relating concepts previously studied with newly learned concepts. After entering a limited face-to-face or during the online learning process, the understanding of students is getting lower, especially the function limit material. It can be concluded that the student's mathematical understanding ability is still relatively low. Therefore, the learning activities' design needs to be more innovative, and teaching materials are arranged to facilitate students' mathematical understanding abilities.

Teachers must arrange and plan good and mature preparations to improve students' mathematical understanding abilities. This is in line with the opinion of [8]; one way to improve mathematical understanding skills is to improve the quality of education, namely by improving the quality of learning. For this reason, learning resources need to be prepared comprehensively to produce innovative learning resources that can train students to think critically and innovatively to practice mathematical understanding skills.

One of the efforts in practising mathematical understanding skills is choosing the right learning model. Accuracy in the application of the learning model is expected to improve students' mathematical understanding abilities, which can facilitate students in finding concepts [1]. Students can understand a concept if they have experience building knowledge. One of the learning models that can help students find mathematical concepts is the discovery learning model.

Hosnan revealed that discovery learning is a model for developing active student learning by discovering themselves and investigating themselves. The results will be loyal and long-lasting in memory and will not be easily forgotten by students [1]. This is in line with the opinion of [1] that acquiring knowledge with the discovery learning process (discovery) will last longer. This is because the knowledge produced is truly meaningful, so discovery learning outcomes have a better and

stronger transfer effect than the results learn more. Based on the explanation above, the discovery learning model is appropriate for facilitating students' mathematical understanding abilities.

Along with the development of Science and Technology, the student worksheets began to be changed into digital form, namely the electronic student worksheets. Electronic student worksheets are a student work guide to facilitate students in implementing learning activities in electronic form that can be seen on desktop computers, notebooks, smartphones, and mobile phones [9]. One of the sites that educators can use to make electronic student worksheets is live worksheets. Electronic student worksheets created using live worksheets can contain motion animation, audio, or video. Incorporating multimedia aspects into the electronic student worksheets is expected to increase students' interest in learning. Student worksheets must be well structured to fit the curriculum, characteristics, goals, and learning objectives to be achieved. In the 2013 Curriculum, the development of learning tools must be in accordance with Permendikbud No. 22 of 2016. The learning tools must also be in accordance with the right models, methods and strategies.

There are problems in the preparation of student worksheets learning mathematics. SMAN teachers in Banguntapan use student worksheets that do not fulfil the standards and are not in accordance with the competence of students in improving students' mathematics learning outcomes [9]. These results are in accordance with the results of previous research that the available mathematics teaching materials are still mostly aimed at developing conceptual understanding [10]. Based on the results of observations and interviews of researchers with a mathematics teacher at SMAN 4 Pekanbaru, I obtained facts about student worksheets in that school. The teacher revealed that during the limited face-to-face learning during the Covid-19 pandemic, the SMAN had not used student worksheets. This is because face-to-face learning time is limited, so the teacher has to catch up with the material.

Based on the problems that the researchers encountered, there needs to be research to develop student worksheets that are more innovative in learning. Worksheets need to be designed so that they can contain the activities needed by students [11]. In addition, well-developed Worksheets can also facilitate various abilities, one of which is problem solving ability [12]. Electronic student worksheets are one of the innovations in learning that allows students to learn to use the student worksheets anytime and anywhere without being limited by class time at school. Students can work on the electronic student worksheets anywhere according to the instructions and interesting features. Developing electronic student worksheets to facilitate students' mathematical understanding skills carried out by educators requires a learning approach and appropriate learning model/method to achieve the expected learning objectives.

In accordance with the formulation of the problem obtained, this study aims to produce electronic student worksheets for the Discovery Learning-Based Mathematics to Facilitate the Mathematical Understanding Ability of Class XI High School Students on Material Limit Functions that are valid and practical.

METHODS

This development research uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. According to [13], the stages of ADDIE include Analysis (Analysis), relating to analysis activities on work situations and the environment so that what products need to be developed can be found. Design is a product design activity as needed. Development (Development) is the activity of making and testing products. Implementation is the activity of using or testing the product. Evaluation is an activity to assess whether each step of the activity and the

product made is in accordance with the specifications. The ADDIE development model chart can be seen in Figure 1. as follows

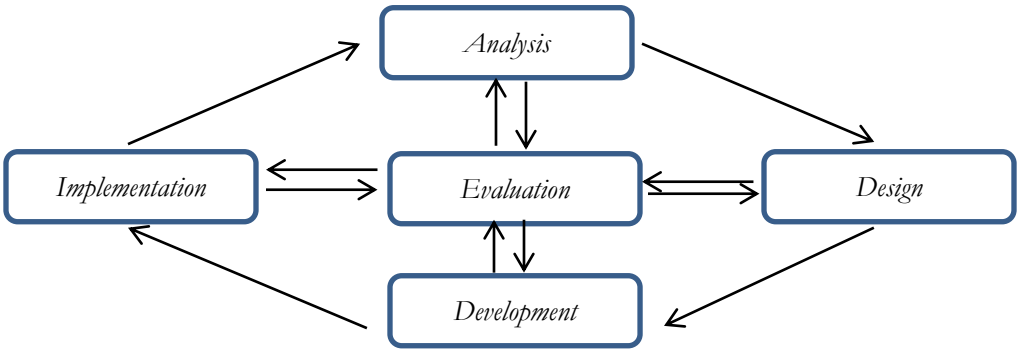

Figure 1. ADDIE Development Model Chart

The analysis stage is the stage where the researcher analyzes the need for developing electronic student worksheets and analyzes the feasibility and development requirements. At this stage, analyzing activities related to problems in compulsory high school mathematics learning and environmental conditions are based on the applicable curriculum. The stages of analysis carried out by researchers include three things: needs analysis, student analysis, and curriculum analysis.

In the needs analysis stage, relevant literature was reviewed, interviews with a mathematics teacher at SMAN 4 Pekanbaru and SMAN 8 Pekanbaru, and a documentation study of student worksheets used in learning mathematics. Then the researchers analyzed the basic problems so that it was necessary to develop electronic student worksheets based on discovery learning on the material limit of class XI functions. Needs analysis is carried out through a review of relevant literature, observations of classroom learning, and interviews to determine the level of students' mathematical understanding abilities. At this stage, the researcher analyzed the student worksheets used as a learning tool and the availability of student worksheets that supported students' critical thinking in learning mathematics.

The stage of student analysis is the study of the characteristics of students based on their knowledge, skills, and development. The analysis of the students was carried out through a literature study on Piaget's theory regarding the characteristics of students and observing the XI class students of SMAN 4 Pekanbaru and SMAN 8 Pekanbaru during the learning process. This analysis aims to determine the level of ability and characteristics of students. The results of the analysis of students are used as an illustration in the development of student worksheets for learning mathematics.

At the curriculum analysis stage, it is carried out to review the applicable curriculum, namely the 2013 curriculum. In the 2013 curriculum, there are competencies that students must achieve. This analysis is carried out by examining Permendikbud Number 37 of 2018 concerning Amendments to the Regulation of the Minister of Education and Culture Number 24 of 2016 concerning Core Competencies and Basic Competencies of Lessons in the 2013 Curriculum in Basic Education and Secondary Education. The researcher then analyzed the Permendikbud applicable to its implementation in schools. Next, the researcher studied KD 3.7 and 4.7 compulsory mathematics subjects for class XI SMA/MA. Curriculum analysis aims to determine which competencies will be developed and the main parts of the material that will be taught and arranged systematically.

After conducting the analysis, the next stage is the design stage. This stage relates the use of the output of the analysis stage to plan a strategy to develop the product. This stage is also known as

making a design (blueprint). The activities carried out at this stage are collecting references related to function limit material, designing systematic writing of student worksheets, determining the layout of student worksheets, designing product validation sheets for validators, and designing student response questionnaires regarding the practicality of the products used.

The development stage is the following design process or the realization of the design stage, which will produce electronic student worksheets that are ready to be tested. At this stage, the researcher develops everything that has been analyzed and prepared in the previous stage, makes electronic student worksheets as attractive as possible, and is made based on discovery learning to facilitate students' mathematical understanding abilities in understanding the concept of limit functions. At this stage, the electronic student worksheets developed first are validated by three validators: lecturers (excluding supervisors and examiners) or teachers. Based on the validation results, if it is valid, it will continue with the implementation stage; if not, it will be revised.

Implementation is a step to apply the electronic student worksheets made in the previous stage, namely development. Researchers conducted a readability test of product development for class XI SMA students online. The readability test was carried out by involving three students. The researcher distributed the electronic student worksheet link via WhatsApp group to the readability test subject and was asked to complete the activities contained in the electronic student worksheet. The researcher then interviewed the readability test subjects through zoom meetings one by one to find an overview of the feasibility and legibility of the electronic student worksheets. Based on the suggestions and comments on the readability test results, the researchers revised the developed products.

Next, the researchers conducted a small group trial consisting of 6 students of Al-Azhar Syifa Budi Pekanbaru high school who had heterogeneous abilities, namely two high-ability students, two medium-ability students, and two low-ability students. Students were selected based on the recommendation of the Al-Azhar Syifa Budi High School teacher Pekanbaru. The researcher also distributed student response questionnaires to students with questions about using electronic student worksheets in the learning process and was asked to provide suggestions and comments.

At the evaluation stage, the researcher evaluates each stage of ADDIE. The purpose of the evaluation stage is to assess the quality of the developed product related to the learning process and results, both after and before implementation.

The types of data in this development research are qualitative data and quantitative data. Qualitative data is obtained from needs analysis and input suggestions from validators or expert lecturers and students on electronic student worksheets. In contrast, quantitative data is obtained from validation sheets given to validators and student response questionnaires to assess electronic student worksheets. This study's data collection instruments were validity and practicality instruments. The validity instrument is in the form of a validation sheet used to validate student worksheets that will be filled out or assessed by the validator. The validation sheet uses a Likert scale consisting of 4 alternative answers, namely 1, 2, 3, and 4, which state very inappropriate, inappropriate, appropriate, and very appropriate. Validation sheets for electronic student worksheets are based on theoretical studies on the requirements for preparing good student worksheets: conformity with didactic requirements, conformity with construction (linguistic) requirements, and conformity with technical requirements. In addition, it is also based on the content's feasibility and the presentation's suitability with the learning approach used. The electronic student worksheet is said to be feasible or valid if the average value given by the validator is at least on the valid criteria. Validation data from the validator was then analyzed descriptively by examining the research results by experts on student worksheets.

The study results are used as input for revising and perfecting the student worksheets that will be developed. The formula for analyzing the validity of electronic student worksheets is as follows [14]:

$$V_s = \frac{T_{se}}{T_{sm}} \times 100\%$$

Information:

V_s : Validation score

T_{se} : Total empirical score from the experts

T_{sm} : Total maximum expected score

The following table 1 presents the validity assessment criteria used

Table 1. Validity Assessment Criteria

Interval (%)	Level of Validity
$85{,}01 - 100$	Very Valid
$70{,}01 - 85$	Valid
$50{,}01 - 70$	Less Valid
$1 - 50$	Invalid

The practical instrument in this study was a student response questionnaire used to determine the practicality of using the electronic student worksheets to be developed. This student response questionnaire consists of a number of questions that will be answered by students after the electronic student worksheet is tested. This questionnaire contains questions that will be answered from four alternative answers using a Likert scale, namely 1, 2, 3, and 4, which sequentially state strongly disagree, disagree, agree, and strongly agree, which was adapted from [14]. The student response questionnaire to assess the practicality of the electronic student worksheets that the researchers will make is designed based on several aspects: appearance, learning content/materials, and ease of use of electronic student worksheets. The formula for analyzing the practicality of electronic student worksheets is as follows [14]:

$$P_s = \frac{T_{re}}{T_{rm}} \times 100\%$$

Description:

P_s : Respondent's score

T_{re} : Total empirical score of respondents

T_{rm} : Total expected maximum score

The following table 2 presents the criteria for the practicality assessment used

Table 2. Criteria for Practicality Assessment

Interval (%)	Level of Practicality
$85{,}01 - 100$	Very Practical
$70{,}01 - 85$	Practical
$50{,}01 - 70$	Less Practical
$1 - 50$	Impractical

RESULTS AND DISCUSSION

The Electronic Student Worksheet (E-LKPD) was developed using the ADDIE development model, which consists of the Analysis, Design, Development, Implementation, and Evaluation stages.

The results obtained at the analysis stage show that learning mathematics carried out by students is still rote, not understanding. This can be seen in students' ability when solving problems that differ from the examples given. Students only memorize the formulas given, so students cannot solve problems different from the examples. The results of observations that researchers have made also show that students who are not active in learning have difficulty understanding the material, so they have low mathematical understanding abilities. This can be seen in students who cannot restate the concepts they have just learned.

At the analysis stage, it was also found that many high school students in Indonesia, especially in Riau, still have low mathematical understanding abilities. The ability to understand mathematics is very important because it is a prerequisite to learning further mathematical concepts. This is in line with what Martin A. Simon said, that the ability to understand mathematics is one of the main goals of mathematics education [3]. The results of the analysis also show that student worksheets used in schools have not been able to facilitate mathematical understanding abilities. This can be seen from the student worksheets used that do not contain learning activities that involve students directly in finding concepts. According to [4], understanding mathematics is one of the strengths that must be considered during the learning process to obtain meaningful mathematics learning that can be stored properly in students' memory.

In the 2013 curriculum, students should be required to find out for themselves with a student-centred approach. One of the learning models that can be applied to overcome this problem is the discovery learning model. There is a positive relationship between the discovery learning model and the students' mathematical understanding ability. Research by [1] explained that knowledge acquisition by the discovery learning process (discovery) would last longer. This is because the knowledge produced is truly meaningful, so discovery learning outcomes have a better and stronger transfer effect than other learning outcomes.

The researcher only designed electronic student worksheets for four meetings with the division of material on the concept of limit function for the first meeting, material on the properties of limit functions in part 1 for the second meeting, material on the properties of limit functions in part 2 for the third meeting, material on limiting algebraic functions (limits). on rational and irrational functions) for the fourth meeting. At the design stage, researchers designed electronic student worksheets according to the discovery learning model and could facilitate students' mathematical understanding abilities. Electronic student worksheets are designed according to the stages of the Discovery Learning model. Trianto stated that there are 6 (six) stages of application of the discovery learning model, including: (1) stimulation (stimulation); (2) problem statement (statement/problem identification); (3) data collection (data collection); (4) data processing (identification of the relevance of the problem to the subject matter); (5) verification (proof); and (6) generalization (concluding) [15]. At the stimulation stage, the learning videos provided aim to stimulate students to be motivated to learn. The stimulation presented as a video makes students more interested in observing it. Incorporating multimedia aspects into electronic student worksheets, namely videos, is expected to increase interest in learning and students' understanding of the concepts. This is in line with [16] opinion that electronic student worksheets can facilitate learning, efficiently use and attract students' interest in learning so that learning becomes more effective. The second phase of the electronic student worksheet is a problem statement. The problems in this phase are contextual and facilitate the KPM indicator of the ability to use, utilize, and choose certain procedures or operations from a

concept algorithmically and apply it in problem-solving. Contextual problems are given so students can think logically and critically in real life.

Next is the data collection phase, on the electronic student worksheets, a table is presented that guides students in discovering the concept of limits. The table given contains the approximate x values for a function f(x), and the first row has been filled with answers so that students understand how to fill in the next row. The data collection phase is designed as a table of questions that students must fill out based on the information they get from various sources. This question table is designed so that students feel challenged and curious to answer the questions given. This is in accordance with the meaning of the scientific approach contained in the 2013 curriculum. Thus, students are more challenged to find the necessary information for themselves, able to answer every problem well, and able to develop their reasoning power.

In the data processing phase, an answer column is given for the solution to the question. Students can process their findings in the previous phase to solve problems. Data processing is an activity to process data and information that students have obtained through interviews, observations, and so on, then interpreted. Next is the verification phase. On the electronic student worksheet, a column is given that compares the hypothesis and the data processing results. Students are asked to re-check whether the temporary answers made by previous students at the problem identification stage are correct. The last is the generalization phase. On the electronic student worksheets, a column is given to upload conclusions from learning. Generalization is a process of drawing conclusions that can be used as general principles and apply to all events or the same problem, considering the results of verification [17].

At the development stage, researchers experienced difficulties and made many revisions in the data collection phase on electronic student worksheets. The question table in the data collection phase is very important in guiding students' discovery of the limit concept so it must be made as good as possible so that students can find the concept of the material being studied. Furthermore, the results of the validation of the electronic student worksheets show that the electronic student worksheets are categorized as very valid, with an average percentage value of 90%. According to Akbar, the product is very valid if it has a validity value of > 85% [14]. The results of the validation of electronic student worksheets based on the DL model on the function limit material for class XI SMA/MA can be seen in Table 3 as follow

Table 3. Validation Results of Electronic Student Worksheets

Rated aspect	**Average Value of the Third Validator of electronic student worksheets Meeting-**				**Average**	**Validation Category**
	1	**2**	**3**	**4**		
The cover display of the electronic student worksheet	100%	100%	100%	100%	100%	Very valid
contents of student worksheets	87%	89%	87%	89%	88%	Very valid
Compatibility of electronic student worksheets with the Discovery Learning Model	97%	99%	94%	97%	97%	Very valid
The suitability of activities on electronic student worksheets with indicators of mathematical	83%	78%	78%	78%	79%	Valid

understanding ability						
Conformity with didactic requirements	88%	85%	90%	85%	87%	Very valid
Conformity with construction requirements	90%	88%	91%	93%	90%	Very valid
Compliance with technical requirements	90%	90%	88%	88%	89%	Very valid
Average	91%	90%	90%	90%	90%	Very valid

Based on the validation results, the aspect with the lowest score is the aspect of the suitability of activities on the electronic student worksheet with indicators of mathematical understanding ability with an average score of 78% with valid criteria. This aspect has the lowest score because the researcher did not write indicators of mathematical understanding ability on electronic student worksheets. Based on the data analysis of the validation results by the validator on the electronic student worksheets that refer to the 2013 Curriculum based on the discovery learning model on the material limit of algebraic functions for class XI SMA/MA students, it is concluded that they have met the validity requirements and can be tested after revisions according to suggestions from the validator. . Furthermore, the results of the readability test on the electronic student worksheets obtained suggestions and comments from the readability test subjects describing readability and feasibility before finally conducting a small group trial.

Based on the results of a small field trial, a student response questionnaire with an average score of 83% was obtained in the practical category, according to [18]. Electronic student worksheets are said to be practical if they reach a value of more than 70%. The results of a small field trial that only obtained an average score of 83% were due to electronic student worksheets that were not often used in schools. Electronic student worksheets are new for students, so adjustments are needed. The display aspect of electronic student worksheets scored 84%. Students complain that the appearance of the electronic student worksheet 1 is not as attractive as the electronic student worksheet two which is the researcher's evaluation material. Aspects of the content/material of the electronic student worksheets scored 84%. In small field trials, students find it challenging to limit material to irrational functions. Furthermore, the ease of use of electronic student worksheets scored 82%. The percentage of student responses to the E-LKPD in small group trials can be seen in Table 4. below

Table 4. Results of Student Response Questionnaires

Aspect	**Student worksheets**				**The average percentage per component**
	1	**2**	**3**	**4**	
Display the contents of the electronic student worksheet	83%	85%	84%	83%	84%
Contents/materials from electronic student worksheets	84%	84%	84%	82%	84%
Ease of use of electronic student worksheets	82%	83%	83%	82%	82%
Practicality Percentage	83%	84%	84%	82%	83%
Practical Category	Practical	Practical	Practical	Practical	Practical

The results of a small field trial on electronic student worksheets obtained an overview of students' mathematical understanding abilities after using electronic student worksheets. Two high-ability students got very good results in discovering the concept of limit material and the practice questions given. High-ability students can answer all the questions in the electronic student worksheet correctly. Meanwhile, for moderately capable students, there are still errors in answering the problems contained in the electronic student worksheets, namely on indicators of using and selecting certain procedures or operations, such as in the practice questions for the limit of irrational functions. Moderately capable students are seen to only master the concept of limits and properties of part 1. Low-ability students do not answer any of the practice questions contained in the electronic student worksheets. This shows that the questions on the electronic student worksheets are still too difficult for low-ability students.

Based on the results of small group trials, the KPM Indicator restates the concept as the indicator that students most master with both high and moderate abilities. Meanwhile, indicators of using, utilizing, and selecting certain procedures or operations from a concept in an algorithmic manner are indicators that highly skilled students master. Based on these results, it is necessary to improve the electronic student worksheets to facilitate the mathematical understanding of students with high, medium, and low abilities. In distributing this research product, researchers need to distribute google forms of student work to teachers who want to use this electronic student worksheet. The settings on the google form of student work must be arranged so that all teachers who want to use this electronic student worksheet can access the students' work.

From the description of validation and small group testing on electronic mathematics student worksheets based on the Discovery Learning model, the material for the limit of functions to facilitate the mathematical understanding of SMA/MA students has met the valid and practical requirements for use by the class XI SMA/MA students.

CONCLUSIONS AND SUGGESTIONS

This development research produces a product in the form of a mathematics E-LKPD which refers to the 2013 Curriculum based on the discovery learning model on the Limit Function material for class XI SMA/MA students, which can facilitate Mathematical Comprehension Ability. Based on the results of research and discussion, conclusions and answers from the problem formulation are obtained that the E-LKPD developed with the discovery learning model on the Limit Function material for class XI SMA/MA students has met the validity criteria with a score of 90% in the very valid category and has met the practical criteria, with a percentage of 83% in the practical category.

Some recommendations that researchers can convey in connection with this research to develop mathematics E-LKPD are mathematics E-LKPD developed in this study through the application of the discovery learning model to facilitate the Mathematical Understanding Ability of XI SMA/MA class students on the Limit Function material. However, other materials and levels can still be developed into mathematics E-LKPD with discovery or other learning models. In this study, researchers only conducted a small group trial for practicality tests of 6 students due to time constraints and conditions due to the COVID-19 pandemic. The researcher suggests to researchers who are interested in following up on this research to study more deeply to conduct large group trials to test the effectiveness. The product produced in this study has met the valid criteria and practical requirements so that it can be used as an alternative student worksheet for teachers to use in the learning process.

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BIOGRAPHY

Nur' Aisyah
Tri avianti studied at (1) SD Negeri 09 Kulim Jaya, (2) SMP Negeri 1 Lubuk Batu Jaya, (3) SMA Negeri 1 Sungai Lala, (4) S1 Universitas Riau. Email: triavianti338@gmail.com

Kartini
Lecturer in the Universitas Riau. She obtained her Strata-3 (S3) in Universitas Pendidikan Indonesia. Email: tin_baa@yahoo.com

Titi Solfitri
Lecturer in the Universitas Riau. She obtained her Strata-2 (S2) in Universiti Kebangsaan Malaysia. Email: titi.solfitri@lecturer.unri.ac.id