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# THE DEVELOPMENT OF PROBLEM BASED LEARNING DESMOS-ASSISTED DIGITAL WORKSHEET FOR TRIGONOMETRY FUNCTION

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## ABSTRACT

Research purposes was to develop digital Student Worksheets (LKPD) based on the Problem Based Learning (PBL) approach on trigonometry material using Desmos and to find out the feasibility analysis this worksheets. The research method uses Analysis Design Development Implementation Evaluation (ADDIE). In the analysis stage, literature studies, observations and interviews were carried out to find out difficulties during blended learning, followed by designing and developing media by utilizing the various features in Desmos. At the implementation stage, validation is carried out to test the feasibility of the e-LKPD by two experts on media and materials. The results of the expert validation on the feasibility of the e-LKPD on the media aspect obtained a value of 73,14% with the appropriate criteria, while the material aspect obtained a value of 75,00% with the appropriate criteria. The most prominent of this e-LKPD is animation which shows the interactiveness and able to spur students to discover and generalize the concept of the graph of the sine function of the unit circle. In the final stage a limited test was conducted in a small group of six students at SMAN 1 Lembang and get a response score of 76,74% was obtained with very good criteria.

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## INTRODUCTION

The construction of mathematical knowledge is a mathematical thinking process that results in the ability of mathematics understanding (Fatimah et al., 2017). The mathematical thinking process is a cognitive activity in accomplishing the mathematics learning process (Abdullah, 2016). The mathematical concepts that learned by the students must be the result of their own constructions. The three principles of constructivism are: (1) knowledge is not passively accepted (knowledge is discovered/constructed by students), (2) new mathematical knowledge is discovered through physical and cognitive activities, (3) students are learning to reflect a social action (Afgani, 2011). Knowledge constructions can be obtained from various scenarios, for instances from students' prior experiences or experiences that had been

prepared or conditioned by the teacher in the classroom. To set up the construction, it can be done by using various methods, approaches, learning models and learning media. One approach that considered being able to construct mathematical knowledge is Problem Based Learning (PBL). In line with this, the results of research that had conducted by showed that learning using the PBL model has a significant effect on students' mathematical communication skills (Kurniati & Suwanti, 2019).

PBL is always started by providing contextual problems. The PBL model is student-centered learning and encourages students to learn through real problems in their daily lives, which are related to the knowledge they have been learned or will be learned. (Rusman, 2011) stated that the PBL process and practice involving cognitive activities to correlate reflection, articulation, and to get on different point of views. PBL is a potential model in order to encourage students to collaborate and elaborate in solving contextual problems through various ways and strategies. PBL provides opportunities for students to be able to contrive a mathematical-problem solving as well. Contextual problems in the PBL model can be provided in teaching materials, for instance in the form of worksheet. Worksheet is an assortment activity that must be accomplished by students to achieve the learning objectives. The use of worksheet in learning activities can change the learning center that was initially teacher-centered become student-centered. Not only that, it also advance students' process skills through activities in order to find out the concepts by themselves. This expectation becomes the basis for teachers to be able to design attractive worksheets, which are accordance with the recent developments. This means that teachers must be able to implement technology in designing worksheet. Teachers need to develop student improve the ability of the high-level mathematical thinking through worksheets (Putra et al., 2017). Somethings to consider in making worksheets are as follows (a) provide interesting examples and illustrations in supporting the presentation of learning materials; (b) provides the possibility for students to respond and measure their mastery of the material through questions, tasks, and so on; (c) the material presented relates to the students' environment (contextual); (d) the language used is simple and does not confuse students (Hendriana et al., 2019). One of some technologies that can be integrated with mathematics' worksheet is Desmos, the website-based application.

Desmos is a web-based graphing calculator that is easy to use and can be accessed for free (Kristanto, 2019). Research conducted by (Kristanto, 2019) showed that Desmos helps students to learn mathematics easier and enhance students' enthusiasm for learning mathematics. This application has the main feature as a graphing calculator and has been developed into an application that has an "ACTIVITY" feature, which allows teachers to create their own worksheets in digital form called digital worksheet (E-worksheet). The digital worksheet assisted by Desmos can be an alternative way for students to learn a material (Oktaviane & Ekawati, 2022). The digital worksheet that designed as teaching material, which was developed with Desmos' assistance, is considered to have a remarkable relation with expected learning objectives (TLS & Herman, 2020). Desmos shows various graphical displays that can help students to visualize various mathematical concepts which are initially considered as abstract. The 2D plotting feature, which has various slider effects, can be used to observe various experiments with different graphs so the mathematics learning is going to be interesting and students' mathematical skills can be enhanced.

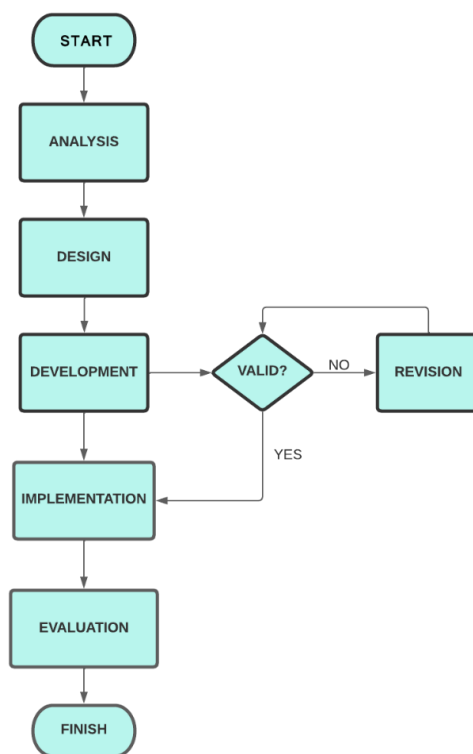
Trigonometry studies the relationship between the sides and angles of triangles. Trigonometry is prerequisite material for other materials such as three dimensions, limits, integrals and has links with certain materials in other subjects (Kepa, 2019). Trigonometry tops the list as a difficult subject to teach (Sultoni, 2018). Trigonometry is also very little liked and only some students are successful in learning trigonometry (Jatisunda & Nahdi, 2019). Students are not

enthusiastic about learning trigonometry because of difficulties in using formulas and think that this material has no benefits in the real world (Sultoni, 2018). In line with this, research conducted by (Suendarti & Liberna, 2021) stated that students' understanding of trigonometry concepts was low. The factor that causes it is that students find it difficult to imagine the object described by the teacher. This is because learning media such as reference books or blackboards cannot be moved like a dynamic model (Wibowo, 2017). These difficulties can be overcome by making trigonometry worksheets assisted by Desmos. With Desmos, material explanations and examples of questions are carried out in stages with the help of pictures or animations (motion pictures), thereby helping users understand the material.

Due to some advantages of using Desmos and the scarcity of digital worksheet development at SMAN 1 Lembang, it becomes a concern for the researcher to conduct research about the development of digital worksheet. The mathematical content used in this research is the graph of trigonometric functions, especially the sine function. Based on the problems above, the researcher is interested in developing PBL-based digital worksheet by using the Desmos application.

## METHOD

This research is a type of Research and Development (R&D), using the ADDIE model of instructional design. The purpose of R&D is to create a product and to analyze its feasibility (Sugiyono, 2013). The ADDIE model is an instructional design methodology, which contains several stages, they are: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation (Nababan, 2020). Figure 1 shows ADDIE stages illustration.



**Figure 1.** The research stages of ADDIE Model

This research was conducted at SMAN 1 Lembang with a small experimental group. Small experimental groups can be carried out by using representatives of 6 students: with low, medium, and high achievement (Sahrul et al., 2020). The representative selection started by arranging students into three groups based on students' achievements. The students'

arrangements are based on the data provided by the teacher. Two students from each group are selected as representatives. Therefore, 6 students are selected as representatives of class X.

The final product of this research is the e-LKPD contained in the Desmos application. So that the e-LKPD feasibility test will be carried out through 3 aspects; Valid, practical and effective (Oktaviane & Ekawati, 2022). The results of the assessment from the experts will be processed by converting qualitative data into quantitative data using a Likert scale, namely by giving a score to each statement item. After getting the score, the average is calculated using the formula (Arikunto, 2010):

$$P = \frac{\sum x}{\sum x_i} \times 100\%$$

After getting percentages of the assessment results, then compare the percentage to the validity criteria. The following is a table of validity criteria:

**Table 1.** Criteria for Feasibility Percentage of Teaching Materials

Percentage	Criteria
0 % - 20 %	Not Feasible
21 % - 40 %	Less Feasible
41 % - 60 %	Decent Feasible
61 % - 80 %	Feasible
81 % - 100 %	Very Feasible

As for the student response data obtained from giving 1 for those who answered "yes" and 0 for those who answered "no". After the score is obtained, then calculate the average score for each indicator and converted into a percentage (Widoyoko, 2013):

$$\text{Students' Responses} = \frac{\text{Students' actual scores}}{\text{Highest possible scores}} \times 100\%$$

The results of the conversion of the percentage of student responses are based on table 2 which was adapted from (Jannah et al., 2021).

**Table 2.** Criteria for Percentage of Students' Response Questionnaires

Interval Score	Criteria
$0\% \leq X \leq 25\%$	Poor
$26\% \leq X \leq 50\%$	Less Good
$51\% \leq X \leq 75\%$	Good
$76\% \leq X \leq 100\%$	Very Good

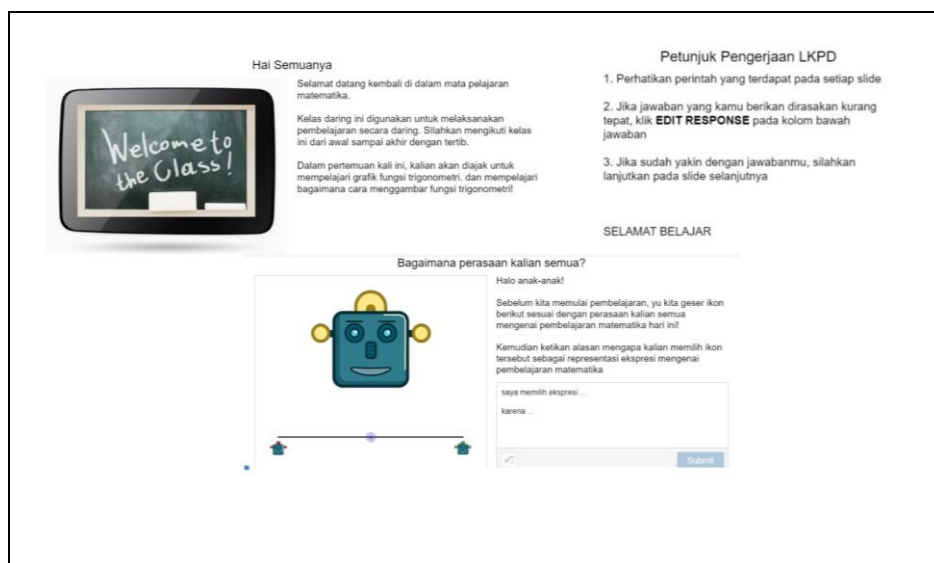
## RESULTS AND DISCUSSIONS

### Results

Preliminary study is the initial stage in conducting research and development model. At this stage, researchers conducted observations and collected data related to learning activities during Covid-19 pandemic. Observations and interviews were conducted to scrutinize how

the implementation of limited offline and online learning in schools. Researcher also consulted about learning topics that will be used in e-LKPD with other mathematics teachers. It turned out that trigonometric functions will be used as the topic, referring to the learning outcomes (Capaian Pembelajaran). Based on observations and interviews, the researcher obtained information that mathematics teachers at SMAN 1 Lembang found several problems in teaching. Teachers were difficult to scrutinize and evaluate students' understanding. Besides, teachers found it difficult to motivate students during limited offline and online learning. The learning activities mostly used Google Classroom (GCR) and teacher deemed that students were less active to participate. During online learning, mathematics teachers at SMAN 1 Lembang had never used ICT in teaching mathematics, especially the graph calculator application. Due to the advantages and disadvantages of Desmos, which can be used as a graphic calculator, the researcher believed that it could be one solution to (1) motivate students in learning mathematics, (2) design attractive worksheet, and (3) create some fun mathematics-learning activities.

The next step was to design the e-LKPD. This e-LKPD was inspired by an activity created by Miss Kate in Desmos. Some of the steps in the slide were modified and adjusted in terms of language and level of difficulty. The slides were created according to learning activities stages (Alur Tahapan Pembelajaran) that had been designed and also were made in essay form in order to analyze students' viewpoint and accuracy (Masriyah et al., 2018). Furthermore, the researcher used several features of Desmos such as, graphs, tables, multiple choice, checkboxes and sketches. Emoticons are also used to make e-LKPD look attractive. Immediate feedback is also created to support worksheets. Feedback here is like, praise if the student's answer is correct, and a warning if the student's answer is wrong. These feedbacks in e-LKPD can be used as mediums for teachers to communicate with students effectively, even in online learning. These feedbacks in digital worksheets can be used as mediums for teachers to communicate with students effectively, even in online learning. (Febriyanti, 2015) stated that direct feedbacks in the worksheet could motivate students to keep trying until they answered correctly and could be used to improve students' motivation and abilities. To create the direct feedback, basic coding skills are required. Some coding examples can be accessed in Computation Layer (CL) feature of Desmos. The digital worksheets consisted of: opening slides, instructions, exercises/activities, and reflections.



**Figure 2.** Design of initial display of e-LKPD slides in Desmos

Before the developed e-LKPD being tested on students, feasibility assessments were carried out by media experts and material experts. Media experts were ICT teacher at SMAN 1

Lembang and the other one was supervisor at the West Bandung Regency Senior High School. While material experts were 2 mathematics teachers at SMAN 1 Lembang. The assessment results obtained from media experts and material experts would be used as references for improvement before the digital worksheet being tested on students.

Assessment from media experts was examined to find out the feasibility of PBL-based digital worksheet by using the Desmos application. The percentage gained from ICT experts was 73.14% with "feasible" category with a slight revision, by the percentage values of each ICT expert were 70.5% and 75.78%. The results of assessments from the ICT experts were presented in the following table :

**Table 3.** ICT Experts Assessment Results

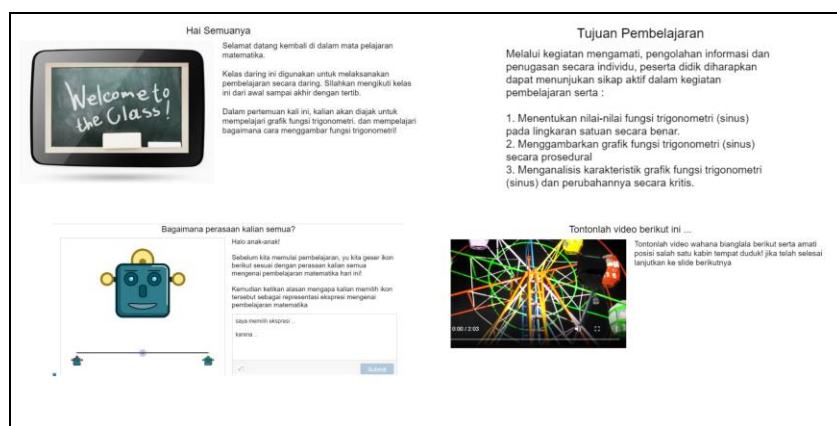
Expert	Total Score	Percentage	Criteria
ICT 1	67	70.5 %	Feasible
ICT 2	72	75.78%	Feasible
<b>Total</b>	<b>139</b>	<b>73.14%</b>	<b>Feasible</b>

Assessment from material experts was examined to find out the feasibility of PBL-based e-LKPD by using the Desmos application. There were several aspects that would be assessed: feasibility of content, feasibility of presentation, and feasibility of language. The percentage gained from material experts was 75%, considered as "feasible", with a slight revision: the percentage values of each material expert were 74% and 76%. The results of the material experts test assessment were presented in the following table :

**Table 4.** Material Experts Assessment Results

Expert	Total Score	Percentage	Criteria
Teacher 1	74	74.0 %	Feasible
Teacher 2	76	76.0%	Feasible
<b>Total</b>	<b>150</b>	<b>75.0%</b>	<b>Feasible</b>

Several revisions given by media and material experts had been revised in the digital worksheet, they were: (1) rearranging the sequence of slides so the students' knowledge about graphs of sine functions would be well-constructed, and (2) adding more slides to enhance students' knowledge about the elements of graphs of the sine functions. The results of e-LKPD after being revised were:



**Figure 3.** Design of initial display e-LKPD after revision

At a later stage, the researcher gave questionnaires to 6 representative students as e-LKPD users. Assessment was carried out by examining the feasibility of contents and presentation that contained some aspects; usefulness (kebermanfaatan), easiness (kemudahan), helpfulness (keterbantuan), and attractiveness (kemenarikan). Therefore, the average percentage from audiences' assessment was 76.735%, considered as "very good": 100% for the usefulness aspect, 50% for the convenience aspect, 87.5% for the helpfulness aspect and 69.4% for the attractiveness aspect. The results of the students' responses were presented below :

**Table 5.** Students' Responses Results

Aspects	Percentage	Criteria
Usefulness	100.0 %	Very Good
Easiness	50.0%	Less
Helpfulness	87.5%	Very Good
Attractiveness	69.4%	Good
<b>Total</b>	<b>76.74%</b>	<b>Very Good</b>

Based on the description of the research results above, the product developed is a PBL-based e-LKPD using the Desmos application on trigonometric function graph material. The thing that underlies the development of these online teaching materials is learning during a pandemic which is less innovative. With the e-LKPD, it makes it easier for students to study learning material anywhere, provided that electronic devices are connected to the internet.

The next stage is the evaluation stage. This stage is a review of assessment of experts, teachers and responses given by students. Based on the results evaluation desmos-assisted digital worksheets development found some information as following:

- a. Based on the assessment of experts, the results of the media expert's assessment were 73.14% and material experts were 75.00%. So the desmos-assisted digital worksheet show the eligibility criteria.
- b. Based on the math teacher's assessment conducted by the math teacher at SMA Negeri 1 Lembang, obtained a percentage of 75,00%. Therefore, according to Table 1 if the percentage of eligibility for teaching materials is between 61% - 80%, desmos-assisted digital worksheet shows the eligibility criteria.
- c. Based on the responses of the 6 students as a sample, the percentage of student responses was 76.74% in the "very good" category. Therefore, according to Table 2, if the percentage of student responses is between 76% - 100%, desmos-assisted digital worksheet show very good criteria.

### **Discussions**

Based on the description of the research results above, obtained the results product is e-LKPD of trigonometric function. This online teaching material is presented in a worksheet contained in the desmos application. This E-LKPD will make it easier for participants students to learn the material. They can study anywhere with the condition that electronic devices are connected to internet. The Desmos application makes it easy for students and teachers to interact, for example discussing material, collecting assignments and quizzes, and easily providing results from learning, (Hourdequin, 2014). It is hoped that the preparation of the material starting from contextual problems will make it easier to construct the concept of graphical functions of trigonometric functions during this online learning.

Assessment of teaching materials according to media experts and material experts states that this e-LKPD is worthy of being tested on students, by adding some input provided by experts. After being declared feasible by experts, teaching materials were tested on mathematics learning activities in schools. In this study, the e-LKPD was tested on 6 class X students at SMAN 1 Lembang. The results of completing the student response questionnaire show that this e-LKPD makes it easier for students to learn. Because with the appearance of interesting teaching materials students will like it, so that students are enthusiastic about learning and encourage students to seek additional information independently, with students having a good learning enthusiasm it is hoped that they can achieve good learning results too. Students are enthusiastic and motivated to work on the trigonometry function questions contained in the Desmos application, because the questions are presented in the form of animations and interactive quizzes with instructions that are easy to follow. This material can be repeated until students understand the whole material. From the teacher's point of view, this e LKPD is very helpful in visualizing abstract mathematical material and is useful in face-to-face and online learning. This is in line with the statement that teaching materials are interesting build students to think hypothetically, and make students explore material independently (Priambodo & Nuryanto, 2020).

## CONCLUSION

The development of electronic worksheets based on Problem Based Learning uses various features found in the desmos application. Among them are activity builder, graphing calculator and computing layer. The purpose of this study was to develop Desmos-assisted worksheets on trigonometry. The results of the development of this LKPD can be accessed at <https://teacher.desmos.com/activitybuilder/custom/6267110e5726564ba4291de4>.

The advantages of this e-LKPD are: (1) The content material are arranged from general to the detailed; (2) Activities designed in form of animation to visualize trigonometry function so easy to understand; (3) Activities designed in interactive form and can be tried by students; (4) Questions are presented in the form of quizzes so students enjoyable to work on. his worksheet also includes graphical calculators for learning mathematics and develop their skills. While the drawbacks of this e-LKPD are the need for a good internet network, and the display on the smartphone or cellphone screen is small and doesn't function properly compared to access via a laptop/PC.

After carrying out all stages of the research, the authors expect future research to: 1) Test the worksheet with a larger experimental group, to evaluate further and more comprehensively the effective aspects. 2) Modify and customize this e-LKPD as you wish, on other math topics, especially topics that require a graphical visual display.

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