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Development of Electronic Student Worksheets based on Problem-based Learning (PBL) in Trigonometry

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Abstract

This research aims to develop learning media in the form of electronic student worksheets based on the Problem-based Learning in trigonometry material for class X Senior High School. This learning media can be used in class or independently. The method used in this study is the research and development method or Research and Development (RnD) which refers to the ADDIE model (Analyze, Design, Development, Implementation, Evaluation). After being tested, the researcher entered the evaluation stage, namely processing the data obtained from the results of the expert validation and trials. The material and language expert validation test scores were 83.33%, media validation tests were 93.48%, teacher validation tests were 99.31%, trials on students in small groups were 91.1%, and trials on students in large groups were 84.2 %. Based on these results obtained an average percentage of 90,284%. From the results of the effectiveness test obtained an average value of 98.27. It can be concluded that Problem-based Learning on trigonometry material can be interpreted as very feasible to be used as learning media for teachers and students.

Keywords: electronic student worksheets; problem-based learning; trigonometry

INTRODUCTION

Education aims to develop the potential of students to become human beings, have noble character, are healthy, knowledgeable, capable, creative, independent, and become citizens of a democratic and responsible. The potential in these students can be developed, one of which is by maximizing mathematics learning at school. According to Eny and Masrukan, mathematics plays a role in developing and forming logical, rational, systematic, and critical thinking (Sulistiani & Masrukan, 2016). In Indonesia, Law of the Republic of Indonesia No. 20 2003 article 37 paragraph 1 states that in the primary and secondary education curriculum it is mandatory to include mathematics, this shows that mathematics is an important subject in the world of education.

However, based on the reality in the field, learning mathematics applied in schools has not been able to optimally improve these abilities. One of the learning difficulties in mathematics occurs at 54 Senior High School in Jakarta. Based on the results of the student needs analysis questionnaire, there were 78% of students who thought that mathematics was a difficult subject. 73% of the total number of students who filled out the questionnaire thought that mathematics was said to be difficult because it was difficult to understand mathematics. In addition, 29% of them think that mathematics still feels abstract and there is no implementation in everyday life. 31% of them think that trigonometry material is material that is difficult to learn in class X. Teaching materials needed by students based on the results of the questionnaire include learning videos by 74%, powerpoint software by 62%, learning modules by 56%, and Student Worksheets by 40%.

Based on the results of teacher interviews, students experience difficulties in learning mathematics due to a lack of understanding and low problem-solving skills. In addition, students are

less enthusiastic about conventional learning and need a stimulus to be motivated to learn mathematics. So, models and teaching materials are needed that can help students learn mathematics material.

Based on the explanation above, the researcher decided to make a teaching material product in the form of an Electronic Student Worksheet which is equipped with learning videos, examples and practice questions, and a brief explanation of the material needed by students, namely trigonometry. The Electronic Student Worksheet that will be developed will also be equipped with various features that can make students interested in studying mathematics material wherever and whenever.

Mathematics Electronic Student Worksheet

Student Worksheets contain learning instructions from a material which is then adjusted to the learning objectives to be achieved (Saputro, 2016). These learning activities may include investigations, problem solving, and drawing conclusions. Learning materials are arranged in regular and systematic stages so that students can follow them easily and precisely and are equipped with questions/exercise. Student Worksheet can be digitized into Electronic Student Worksheet. According to Yosita, Electronic Student Worksheet is defined as a learning tool that is designed electronically, contains systematic and interesting material to achieve the expected competencies (Sari, 2019). According to Lathifah, Hidayati, Zulandri, electronic student worksheet are designed and created in accordance with the objectives to be achieved in the learning process and the creativity of each teacher where students can access these electronic student worksheet via the internet network (Lathifah et al., 2021). Electronic student worksheet is expected to help students to better understand the material provided by the teacher so that learning objectives can be achieved. According to Yuliandrianti and Susilawati, the application of Problem-based Learning in student worksheet can make learning activities more meaningful if the student worksheet contains contextual or real problems, which are able to encourage students' motivation and interest in learning related concepts (Yuliandriati et al., 2019).

In Mifta Abdillah and Dwi Astuti's research with the title "Development of Student Worksheets based on Problem-based Learning on Angle Topics" obtained results that were suitable for use by students and teachers (Abdillah & Astuti, 2021). The Problem-based Learning model used in student worksheet includes the same stages as the Problem-based Learning stage theory with content modifications in it. The development of electronic student worksheet was carried out by Laely Faizatun in chemistry subject with the title "Development of Electronic Student Worksheet based on Problem Based Learning (PBL) with Ethnoscience content in Class X Redox Reaction Material at MAN 1 Cirebon" with very valid results to use (Fuadah, 2021). Electronic worksheets developed using the Problem-based Learning model include problem orientation, learning organization, investigation, presentation of results, reflection and evaluation. In appearance there are learning videos and animations in the presentation of the electronic student worksheet. The form of electronic student worksheet was also developed by Yunita Triwiyanti Pribadi, Dudung Amir Sholeh, Yetty Auliaty in 2021 with the title "Development of Electronic Student Worksheet on Problem-Based Learning Material for Fractions in Grade IV Elementary Schools" (Pribadi et al., 2021). In the electronic student worksheet there is an animated video that can be accessed via a link and QR code. The choice of colors in electronic student worksheet is also an important matter so that students are interested and comfortable while using electronic student worksheet for learning.

Problem-based Learning

According to Ridwan, Problem-based learning is a learning model that adheres to cognitive psychology theory, especially Piaget and Vigotsky's theory (constructivism), which means that in this model theoretical thinking processes are applied but there are also social practices in it (Sani, 2019). According to Darmadi, Problem-based Learning is a learning method that can challenge students to learn how to learn, work in groups to solve problems together (Darmadi, 2017). The problem given is a problem that is used to bind students to their curiosity. Heru Cahyadi believes that students will have adequate skills and abilities at the peak of the Problem-based Learning process and prepare them for

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the world of professional work, where they are required to think critically, individually and in work groups and skills to solve complex problems are important. for success (Cahyadi, 2019).

The Problem-based Learning model used in this research is the Problem-based Learning model according to Arends. The syntax for Problem-based Learning according to Arends in Ridwan (Sani, 2019) includes,

1) Problem Orientation Stage. At this stage, the teacher discusses learning objectives, describes logistical needs, and motivates students before learning begins so that students are actively involved.
2) Learning Organization Stage. At this stage, the teacher assists students in defining and organizing learning in order to be investigated further with the aim of solving problems.
3) Investigation Stage. The teacher guides students to get correct information, conduct investigations, and seek explanations from the solutions that have been found.
4) Problem Presentation Stage. The teacher helps students in planning products or products that are appropriate and relevant to use when presenting work results.
5) Reflection and Evaluation Stage. The teacher helps students in evaluating what they have done until the final result is created.

METHOD

This study uses Research and Development methods, namely to develop a learning product in the form of electronic student worksheets. This research was conducted on students at 54 Senior High School in Jakarta which is located at Jl. East Jatinegara IV No.8, RT.8/RW.7, Rw. Bunga, Jatinegara District, East Jakarta City, Special Capital Region of Jakarta. The stages of this research are based on the ADDIE model development procedure, namely Analyze, Design, Development, Implementation, and Evaluation .

At the analysis stage, the researcher conducted a needs analysis using data including student questionnaires, student and teacher interviews, class observations, and data collection on students' trigonometry values. These data are then processed and studied with several theoretical studies that have been carried out by researchers to find a solution. After that, at the design stage, the researcher designs and compiles the framework and big picture of the product starting from the content framework of the electronic student worksheet, the material concept, determining the design model of the electronic student worksheet, to the platform that will be used in the process of making and displaying the electronic student worksheet.

At the development stage, the researcher made the contents of the electronic student worksheet first and then presented them using attractive designs. Researchers designed electronic worksheets with the help of the Canva design website, then compiled them using Microsoft Word. Researchers made learning videos using the help of Microsoft power-point and recorded using Active Presenter. student worksheet in Microsoft Word with learning videos combined using the Flip PDF Professional software. Product results can be presented online or offline. However, in the process of making it, researchers experienced problems so they switched to using the Heyzine website to display electronic student worksheets with animations and more complete features. The product was then revised and improved based on corrections and suggestions from two material and language experts, two media experts, and one math teacher. Products that have been repaired can already be tested in the field, namely to students in small and large groups.

In the small group trial, 10 random data were taken from students at 54 Senior High School in Jakarta and in the large group trial, 28 random data were taken from students at 22 Senior High School in Jakarta. This difference in schools is justified in development research because development research is not bound by time and place of implementation. Data collection in the small and large group trials was in the form of questionnaires and student interviews regarding electronic student worksheets in order to get input and suggestions for re-development of electronic student worksheets for the better. Data in student questionnaires are calculated using a scale of one to four with the following details,

TABLE 1. Questionnaire Filling Score (Hadi, 1991)

Answer Choices	Code	Weight Score
Very Good	SB	4
Good	B	3
Poor	K	2
Very Poor	SK	1

After the data is collected where previously the data was quantitative data, it is then converted into qualitative data by calculating the percentage of the total score that has been obtained.

$$Percentage = \frac{\sum score\ obtained}{\sum maximum\ score} \times 100\%$$

Then, the data that has been obtained in the form of a percentage will be converted based on the feasibility interpretation table 2.

TABLE 2. Interpretation Score (Hadi, 1991)

Percentage Score	Interpretation
0% - 25%	Not feasible
25% - 50%	Decent Enough
50% - 75%	Eligible
75% - 100%	Very Eligible

RESULT AND DISCUSSION

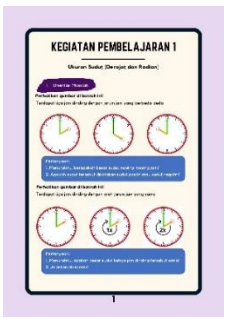
Data Analyze

Electronic student worksheets were developed using the Problem-based Learning model. This learning model is a solution to the problems that exist in students based on the theoretical studies that have been described in the background section. The researcher made an initial draft of the Electronic student worksheets based on existing references and then the researcher adapted it into an electronic student worksheets design with the Problem-based Learning model. The following is an example of the display on the final product of the developed electronic student worksheets.

(a) Front Page Display

(b) Instructions for Use

(c) Basic Competency, Learning Objectives, and Learning Indicators



(d) Problem Orientation Stage

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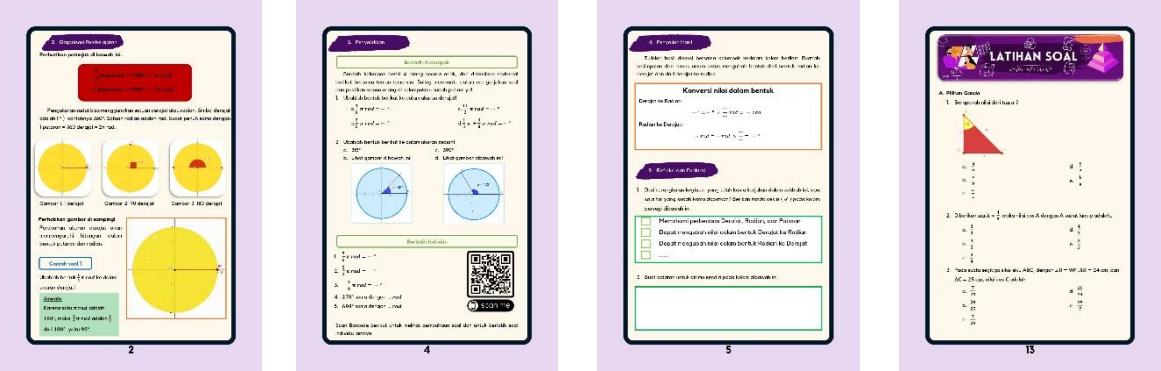

(e) Learning Organization Stage (f) Investigation Stage (g) Results Presentation Stage (h) Reflection and Evaluation Stage

FIGURE 1. Electronic Student Worksheet Design

After the initial draft was completed, the researcher revised the initial draft to two material and language experts as well as two media experts. The results of the corrections from the experts then the researchers corrected them. After being corrected, the results of the improvements were returned and re-assessed by experts and produced a second draft after revision. In the next stage, the researcher validated the mathematics teacher with the same process so that the third draft product was produced. At the implementation stage, researchers conducted trials on students in small groups and large groups. Small group trials were conducted by 10 students at 54 Senior High School. In this small group trial, there were no corrections or suggestions that needed to be made, so the researchers immediately proceeded to the next process, namely a large group trial of 27 students at 22 Senior High School. In the large group trials, the researchers conducted them in different schools in order to adjust the research time to the time the trigonometry learning material took place. This is not a problem in development research because development research is not bound by place and time. From the results of small and large trials, the results of questionnaires and interviews with students and teachers were obtained. These results are used by researchers to redevelop learning products into the third draft. The following are the results of the assessment of learning products starting from the expert validation stage to large group trials by students.

TABLE 3. Electronic Student Worksheets Result

Research Stages	Interpretation	Assessment Results
Material and Language Expert Validation Results	83,33%	Very Eligible
Media Expert Validation Results	93,48%	Very Eligible
Teacher Validation Results	99.31%	Very Eligible
Small Group Trial Results	91,1%	Very Eligible
Large Group Trial Results	84,2%	Very Eligible

First of all, the researcher validated by two instrument validators to check whether the instrument the researcher made could be used as an assessment guide or not. After checking and repairing, the researcher validated the product with two material and language validators which were carried out by two lecturers at the Mathematics Education Study Program State University of Jakarta. The validation instrument for material and language experts consists of 30 questions about evaluating learning products. From the results of the assessment of the two material and language expert validators, an assessment was obtained with an average of 83.33%. This value can be interpreted as a very feasible product by material and language experts. Then, the learning products were reassessed by media experts. The media expert validation was carried out by UNJ Computer Science lecturers and Mathematics Education State University of Jakarta lecturers as many as 23 questions about evaluating

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learning products. The results of the assessment of the two media validators obtained an assessment with an average of 93.48%. This value can be interpreted as a very feasible product by media experts.

After the product is assessed by material and language experts as well as media experts, the learning product is validated by the mathematics teacher. This validation was carried out by 54 Senior High School teachers with 29 assessment items. From the validator by the teacher, an assessment of 99.31% can be interpreted as very feasible. The researcher then proceeded to the next stage, namely trials on students in small groups and large groups. Small group student trials were conducted on 10 students with 20 questions. From the trial of small group students, a score of 91.1% was obtained which can be interpreted as very feasible. Then, the researcher continued the tryout by students in large groups of 29 students with the same questions as the small group tryout. At this stage, an assessment of 84.2% was obtained which could be interpreted as very feasible with several correction notes and input from students in the form of confused questions, ambiguous question editors, and unclear displays or images. These suggestions and input are useful for researchers in developing better learning products. Based on the results of assessments from material and language expert validators, media expert validators, teacher validators, student trials in small and large groups, the average final assessment of learning products is 90.28% which can be said to be very feasible.

CONCLUSION

From the results of the research and discussion it can be concluded that the development of Problem-based Learning Electronic Worksheets on trigonometry material consists of three parts, namely introduction, content, and closing and is available in three sub-chapters, namely angle measurements (degrees and radians), trigonometry comparisons on triangles right angles, and trigonometric ratio values for special angles. The introduction includes the title page, preface, table of contents, instructions for use, concept maps, competencies and learning objectives. In terms of content, the electronic student worksheets contains three sub-chapters which were developed on the basis of Problem-based Learning. Finally, the closing section contains a bibliography.

The Problem-based Learning electronic student worksheets in trigonometry material meets the very feasible criteria with an accumulated percentage of above 75% based on the assessment of:

1) The material and language expert validator stated that this Electronic electronic student worksheets received the "Very Eligible" category with an average percentage gain of 83.33%. The media validator stated that this electronic student worksheets was in the "Very Eligible" category with an average percentage gain of 93.5%. The validator by the teacher stated that this electronic student worksheets was in the "Very Eligible" category with an average percentage gain of 99.305%.
2) In experiments on students in small groups, this electronic student worksheets received the "Very Eligible" category with an average percentage gain of 91.1% and in experiments on students in large groups, this electronic student worksheets received the "Very Eligible" category with an average -an average percentage of 84.2%.

Based on these results it is known that the average percentage of the eligibility value of the developed teaching materials is 90.28%, or can be interpreted as very feasible. The value obtained is very good for use in learning for teachers and students.

Based on the results of research and development of electronic student worksheets with the Problem-based Learning model on trigonometry material for class X SMA/MA students, there are suggestions for further research to be carried out, including the following: 1) This electronic student worksheets can be redeveloped in further research with different learning materials or models. 2) The development of digital-based learning products can be re-examined using platforms . 3) This research can be continued to quantitative research with a measure of success in improving students' mathematical abilities.

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