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THE DEVELOPMENT OF PROBLEM BASED LEARNING GEOGEBRA-ASSISTED TEACHING MATERIALS TO IMPROVE MATHEMATICS COMMUNICATION ABILITY OF VOCATIONAL SCHOOL STUDENTS

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ABSTRACT

This study aims to produce teaching materials based on the GeoGebra-assisted Problem Based Learning approach that are valid, effective and practical to improve mathematical mathematical communication skills in linear programming material. The subjects in this study werw 30 students for a limited trial, 60 students for a broad trial, and 60 students for product testing including 30 experimental class and 30 control class. The instruments used in this study were interview sheets, student observation sheets on learning, response questionnaires to learning, validation questionnaires, five questions about mathematical communication ability tests, and non-test questionnaires for students' self-confidence. The results of this study indicate that the process of developing teaching materials is carried out well and the product is feasible to use, mathematical communication skills and self-confidence of students who receive learning using the GeoGebra-assisted Problem Based Learning method are better than students who receive learning using the usual approach, difficulties during learning do not indicate a high level of difficulty, in terms of mathematical communication problems students have difficulty in perfoming algebraic operations and more than half of students respond positively to learning.

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INTRODUCTION

The implementation of the 2013 curriculum that is currently being implemented can have a positive impact on learning outcomes. The curriculum used is required to be creative and

innovative in designing learning, so that learning is active, creative, fun and students are motivated to learn independently. Problem Based Learning is an active learning strategy that is highly recommended in the implementation of the 2013 curriculum. This learning strategy aims to train students to learn independently, using real-world problems as a context for students to solve life problems.

According to Oviyani (2017), mathematics is one of the subjects taught at all levels of education which has a very important role in mastering science and technology. Student teaching and learning activities are the subject and object of teaching activities. Learning outcomes are influenced by the ability of students and the high or low or the effectiveness of the learning process

The importance of understanding linear programming material can be used in everyday life such as business, economics and in a number of engineering science calculations (Maure et al., 2020). For example, in material economics, it functions as an objective related to the optimal arrangement of resources to obtain maximum profit or minimal cost, while the constraint function describes the limits of available capacity that are optimally allocated to various activities. Linear programming material is useful in modeling various types of problems in planning, route design, scheduling, assignment, and design.

According to Ruseffendi (Hodiyanto, 2017) the largest part of mathematics that students learn at school is not obtained through mathematical exploration, but through direct notification. This is in accordance with the results of a preliminary study that the author did in one of the Vocational High Schools in Cimahi City, that the learning conditions that took place in the classroom made students tend to be passive. In general, students think that mathematics is a difficult subject to understand so that not a few students are afraid of mathematics. The lack of enthusiasm of students results in low mathematics learning outcomes.

In the results of research that has been carried out through preliminary studies, students still find it difficult to understand problems in mathematical communication problems in linear programming material. This is because during the learning process the teacher tends to provide material and explain the material directly, provide examples of questions, and provide practice questions to find out how far students have understood in the learning process so that the next activity is. By getting used to students getting practice questions according to examples, students cannot think broadly and must comply with the examples given by the teacher. Students tend to have more difficulty when working on problems in the form of problem solving. This is supported by the opinion of Nurjanah & Sujadi (2018), that students have difficulty solving linear programming problems, because students do not understand the principles in linear programming material used when solving linear programming problems.

Mathematical communication skills as a student's ability to convey mathematical ideas both orally and in writing through dialogue/interrelationship events that occur in the classroom environment, where message transfer occurs. Haji & Abdullah, (2016) explained that the importance of communication in learning mathematics, because mathematics as language and mathematics learning as social activity. As a language, people use mathematics to convey ideas by using symbols and meanings that have a single meaning.

However, in reality, mathematical communication skills are still relatively low. This is supported by Yanti's opinion, (2019) that students' mathematical communication skills are still relatively low. A similar statement was also explained by Rahmawati, (2018) the mathematical communication skills of SMK students on SPLDV material are still in the low category.

In addition to mathematical communication skills, there are affective aspects that contribute to the success of students in solving mathematical problems well. The affective aspect is self-confidence. According to Afiatin & Martaniah, (1998) one way to grow self-confidence is to provide a democratic atmosphere or conditions, namely individuals are trained to be able to express opinions to other parties through social interaction, trained to think independently and given a safe atmosphere so that individuals are not afraid. make a mistake. If students have good self-confidence, then students can be successful in learning mathematics, able to support students' motivation and success in learning mathematics. Students will tend to understand, find, mathematical problems they face for the expected solution. According to TIMSS (Martin, 2008) shows that the self-confidence of Indonesian students is still low below 30%. Self-confidence is having good mathematics, being able to learn mathematics quickly and never giving up, showing confidence in their mathematical abilities, and being able to think realistically. Thus, it can be concluded that self-confidence is important for students to have.

To improve mathematical communication skills and affective aspects can be achieved optimally, one of the efforts for this is by making teaching materials that can make students more active, creative, and able to train their learning independence. As said Ramdani, (2012) that overall teaching materials are very important for learning activities. Through student worksheet, many activities are carried out by students in working on practice questions with the aim of making it easier for them to understand a material. It is necessary to develop LKS so that LKS are more creative and not the same as usual. However, in fact choosing or determining appropriate teaching materials to help students achieve the competencies to be achieved is a problem that is often faced by teachers. This is due to the fact that in the curriculum or syllabus, teaching materials are only written in outline in the form of basic materials (Ministry of National Education, 2006). The learning process in the 2013 curriculum applies five learning activities, namely observing, questioning, experimenting, associating, and communicating.

One method that can be applied to learning linear programming material is problem-based learning or Problem Based Learning. Problem Based Learning model is defined as a learning model that involves students to try to solve problems by going through several stages. According to Rusmono (2014), the stages of Problem Based Learning are student orientation to problems, organizing students to learn, helping independent and group investigations, developing and presenting work, and analyzing and evaluating problem solving processes.

In linear programming material, the researcher will use GeoGebra which will be given to students in order to arouse students' enthusiasm, carry out well and make it easier for students to understand linear programming material. GeoGebra is dynamic software that can be used as a tool in learning mathematics. GeoGebra is very useful for demonstrating and visualizing mathematical concepts, especially geometric objects. The use of learning media assisted by GeoGebra can provide opportunities for students to learn discovery and the teacher acts as a facilitator who provides an active learning environment so as to create meaningful learning.

Thus, one of the efforts to help improve the mathematical communication skills and self-confidence of vocational high school students is to develop an innovative teaching material product so that it can facilitate teachers and students in the learning process. So based on the description above, the author will conduct research that aims to develop teaching materials on linear programming materials using a geogebra-assisted problem based learning approach to improve mathematical communication skills and self-confidence of SMK students.

METHOD

The research method used is the development method with the aim of developing teaching materials on linear programming material with a geogebra-assisted problem based learning approach. The development model used is from Borg & Gall. There are 12 stages of

development research in this research, including; 1) research and data collection, 2) planning and development of teaching materials, 3) initial development of teaching materials, 4) validation of teaching materials, 5) revision of initial teaching materials, 6) limited trials of teaching materials, 7) revision of advanced teaching materials, 8) extensive testing of teaching materials, 9) revision of final teaching materials, 10) product trials, 11) revision of improved teaching materials, and 12) product implementation and socialization. The limited trial was carried out by 30 students in class XI TKRO 1, for the broad trial, 30 students in class XI TKRO 2 and 30 students in class XI TMK 1 and for product testing the experimental class consisted of 30 students in class X TMK and 30 students in the control class. X TITL.

The instruments used in this study were interview sheets, reading sheets, response questionnaires to learning, validation questionnaires, five questions on the mathematical communication ability test, and non-test self-confidence questionnaires. Interview sheets are used to collect information in the preliminary process for teachers, validation sheets are given to validators (material experts and ICT experts) with the aim of knowing what aspects have not been achieved in the designed teaching materials, reading sheets are used to see readability students to teaching materials at the stage of limited trials and extensive trials, response questionnaires were distributed and then filled in by students, this was done to see the practicality of the teaching materials developed, while the mathematical communication ability test was carried out to see the effectiveness of using teaching materials based on a problem approach. geogebra-assisted based learning in the learning process.

The data collection technique in this study was in the form of description questions to see students' answers in solving mathematical communication problems on linear programming material. The processing of the results of the answers to the test questions was analyzed using mathematical communication indicators, including; (1) linking real objects, pictures and diagrams into mathematical ideas; (2) explain ideas, situations and mathematical relations, orally and in writing with real objects, pictures, graphs and algebra; (3) expressing everyday events in mathematical language/symbols; (4) listening, discussing and writing about mathematics; (5) read with understanding a written mathematical presentation; (6) making conjectures, compiling arguments, formulating definitions and generalizations. Data processing techniques to see the validity of teaching materials based on the geogebra-assisted problem based learning approach using product validity analysis, data processing techniques to see the level of practicality of teaching materials seen through student response questionnaires using practicality analysis, and processing student final tests using effectiveness analysis.

The validity analysis technique was assessed by an ICT expert validator obtained from a questionnaire filled out by one Siliwangi IKIP lecturer and one KBB teacher, while the assessment by a material expert validator was obtained from a questionnaire filled out by one Siliwangi IKIP lecturer and two SMK teachers in the City. Cimahi, then analyzed in order to see the validity of the LKS developed. Measurement of validity using a Likert scale. The following are the steps for measuring validity using a Likert scale: a) Scores for positive statements are, "strongly agree = 4", "agree = 3", "disagree = 2", and "strongly disagree = 1". Likewise, on the contrary, for negative statements, the score becomes, "strongly agree = 1", "agree = 2", "disagree = 3", and "strongly disagree 4". b) Calculate the total score given by the expert validator. c) Calculation of the validity value used the following formula (Arikunto, 2019):

$$V = \frac{f}{N} \times 100\%$$

Information:

V : Final score

f : Score

N : Maximum score

To see the interpretation of the calculation results, the following categories are used:

Table.1 Validity Category

Score	Category
$81\% - 100\%$	Very Valid
$61\% - 80\%$	Valid
$41\% - 60\%$	Enough Valid
$21\% - 40\%$	No Valid
$0\% - 20\%$	Very not Valid

Data analysis technique using percentage. Teaching materials based on the geogebra-assisted problem-based learning approach can be said to be practical if students can understand the content of the material on the learning device and can construct a geogebra-assisted problem-based learning approach properly. Data analysis used percentages based on student response questionnaires with the following steps: a) Scores for positive statements, namely, "strongly agree = 4", "agree = 3", "disagree = 2", and "strongly disagree = 1" . Likewise, on the contrary, for negative statements, the score becomes, "strongly agree = 1", "agree = 2", "disagree = 3", and "strongly disagree 4". b) Calculate the total score of the responses given by students. c) Calculation of practicality value is used the following formula (Lestari, 2018):

$$P = \frac{f}{n} \times 100\%$$

Information:

P : Percentage of answers

f : Answer frequency

n : Many respondents

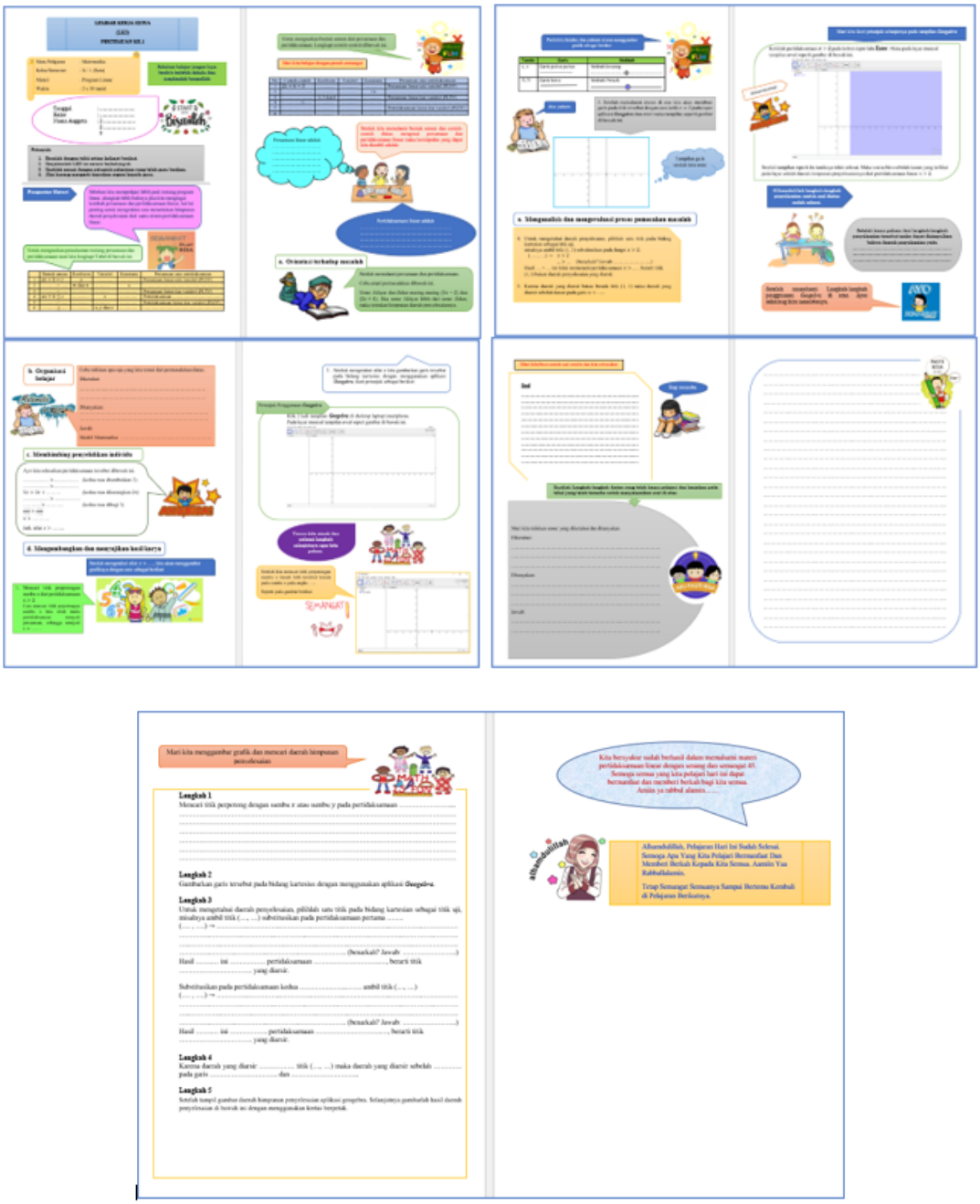
Table.2 Categories Using Percentages

Nilai	Kategori
$81\% - 100\%$	Very Valid
$61\% - 80\%$	Valid
$41\% - 60\%$	Enough Valid
$21\% - 40\%$	No Valid
$0\% - 20\%$	Very not Valid

RESULTS AND DISCUSSION

Results

The stages carried out in this research are starting from a preliminary study regarding the need for teaching materials to be developed through interviews with teachers at vocational high school Karya Bhakti Pusdikpal. In the learning process, teachers tend to provide material contained in texbooks, explain the material directly and provide examples of questions. After conducting a preliminary study, the researchers then designed teaching materials in the form of worksheets based on a geogebra-assisted problem-based learning approach. Here the author presents the appearance of the LKS that was developed:



Picture 1 student Worksheet design

After the design stage is carried out, then the teaching materials are validated by validators from material experts and ICT experts, in order to find out what aspects are lacking in the teaching materials that have been designed by researchers. The results of material expert validation and ICT expert validation of LKS teaching materials can be seen in Table 3 and Table 4 below:

Table. 3 Recapitulation of Material Expert Validation Assessment Before and After Improvement by Category

Aspects Observed	Item Number	Persentase (%)	
		Early stage	Final Stage

Identity Clarity and Completeness	1, 2, 3, 4, 5, 6, 7, 8	93.33	93.33
Time Allocation Accuracy	9, 10	73.34	80.00
Clarity of Formulation of Indicators and Objectives with KI and KD	11, 12, 13, 14	75.00	78.33
Suitability with Learning Objectives	15	80.00	80.00
Suitability to Students' Learning Abilities and Needs	16, 17	80.00	80.00
Suitability with Learning Objectives	18	80.00	86.67
Suitability with Learning Materials	19	80.00	86.67
Suitability with Student Characteristics	20, 21	80.00	86.67
Compliance with Process Standards	22, 23, 24	86.67	86.67
Suitability of Learning with PBL Approach	25, 26	86.67	86.67
Suitability of Learning Resources with Learning Objectives	27	86.67	86.67
Compatibility of Learning Resources with Learning Materials	28	93.33	93.33
Suitability of Learning Resources with Student Characteristics	29	80.00	80.00
Appropriateness of Assessment Techniques with Learning Objectives	30, 31, 32	80.00	84.45
Existence and Clarity of Assessment Procedure	33, 34	86.67	86.67
Average Percentage		**84.12**	**86.08**
Feasibility test		**Worthy**	**Very Worthy**

Based on Table 3, it can be seen that the percentage of all aspects in the teaching materials have reached the "Very Eligible" category at the final stage. So that LKS teaching materials can be used directly.

Table.4 Assessment of Validation of ICT Experts in the Early and Late Stages Based on the Observed Aspects Aspects Observed

Rated aspect	Item Number	Persentase	
		Early stage	Final stage
Visual display	1, 5	85%	85%
Educative	2, 3, 4, 6, 7, 8	84%	88,33%
Average Percentage		84%	88%
Feasibility test		**Worthy**	**Very Worthy**

Based on Table 4, seen from the "visual appearance" aspect, the final stage got a score of 85% with the "Very Eligible" category, then from the "educative" spec, the final stage of learning got a score of 88.33% with the "Very Eligible" category, so that the average the percentage of the final stage of ICT expert validation assessment recapitulation is 88% with the "very feasible" category to use.

After the initial validation stage, the researcher conducted a limited trial at the Pusdikpal KB Vocational School with a total of 30 students. The researcher simulates learning using the developed teaching materials and then asks students to fill out a readability questionnaire for the teaching materials, in order to find out what is lacking from the teaching materials being developed. Here the author presents the results of a limited trial.

Table 5 Results of the Student Readability Questionnaire on Teaching Materials in the Trial Limited

Number	Statement	Respon	
		Yes	No
1.	Do you understand the problems given in the LKS?	22 73,33%	8 26,66%
2.	Do you understand the instructions listed on the worksheet?	20 66,66%	10 33,33%
3.	Can you understand the language listed in the LKS?	18 60%	12 40%
4.	Can the illustrations in the worksheet help you get information?	20 66,66%	10 33,33%
5.	Can the worksheet help you understand the material?	21 70%	9 340%
Average Percentage		**67,33%**	**32,67%**
Feasibility test		**Worthy**	

Based on Table 5, it is known that the average percentage of students who respond well to "yes" reaches 67.33% with a decent category. The next stage is a broad trial. The following is a table of the results of extensive trials that the author has carried out at SMK KB Pusdikpal.

Table 6 Results of the Student Readability Questionnaire on Teaching Materials in the Extensive Trial

Number	Statement	Respon	
		Yes	No
1.	Do you understand the problems given in the LKS?	52 86,66%	8 13,34%
2.	Do you understand the instructions listed on the worksheet?	50 83,33%	10 16,67%
4.	Can you understand the language listed in the LKS?	53 88,33%	7 11,67%
5.	Can the illustrations in the worksheet help you get information?	47 78,33%	13 21,67%
6.	Can the worksheet help you understand the material?	55 91,66%	5 8,34%
Average Percentage		**85,66%**	**14,64%**
Feasibility test		**Very Worthy**	

Based on Table 6, it is known that the average percentage of student readability at the broad trial stage who responded "yes" reached 85.66% with the "very feasible" category. In general, the teaching materials are good and appropriate. Comments, shortcomings, suggestions, and criticisms point to the wide use of teaching materials. Then to improve the quality, improvements were made in the form of minor adjustments to the writing and pictures in certain

parts to make it look more attractive and easy for students to understand. After extensive trials, evaluations, and minor improvements were made to the teaching materials. Researchers then conduct product trials.

Table 7 Recapitulation of Student Responses on Experimental Class Product Trials

Number	Category Statement	Score	
		$\bar{X}$	%
1.	Have an interest and enthusiasm in learning	20,03	83,47%
2.	Able to overcome difficulties and dare to try new things (usefulness of teaching materials)	13,03	81,46%
3.	Able to understand learning material	12,93	80,83%
4.	Ease, suitability and sufficient time	19,83	82,64%
Average Percentage		**82,10%**	
Interpretation		**Very good**	

Based on the results of the calculations in Table 7, the average percentage of student answers as a whole is 82.10%. This shows that the average percentage of student responses to learning using teaching materials based on Problem Based Learning assisted by GeoGebra has a positive response. This means that the teaching materials used during product testing are very practical to use.

Discussion

Based on data processing from teaching materials developed in the form of worksheets, the results obtained that teaching materials based on the GeoGebra-assisted Problem Based Learning approach on linear programming materials that have been developed by the author in terms of the results of validity by material experts and ICT experts reached the "very feasible" category. Based on the results of research from students on their responses after using the developed teaching materials, overall it can be stated that the developed teaching materials fall into the "very feasible" category.

From the explanation above, it is found that the development of teaching materials based on the GeoGebra-assisted Problem Based Learning approach is good enough to be used to improve mathematical communication skills in linear programming material. This is in line with research by Aris (2013), which developed teaching materials for the learning process oriented to mathematical communication skills which resulted in the teaching materials being developed in a very good category so that the test results of students' mathematical communication skills achieved high scores. thanks to the developed teaching materials.

CONCLUSION

Based on the results of data processing, the conclusions obtained are that teaching materials based on the GeoGebra-assisted Problem Based Learning approach on linear programming materials are in the very feasible category and teaching materials based on the GeoGebra-assisted Problem Based Learning approach on linear programming materials are in the very feasible category.

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