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Development of Mathematics Learning Devices with Problem Based Learning Models Assisted by Geogebra to Enhance Student's Understanding of Mathematical Concept

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ABSTRACT
This study aims to produce a mathematics learning device with Problem Based Learning (PBL) models assisted by Geogebra to enhance student's understanding of mathematical concept on a linear program that has been valid, practical, and effective. Method of research used Research and Development (R and D) and the development model design used the ADDIE model with five stages are: 1) Analysis, 2) Design, 3) Development, 4) Implementation and 5) Evaluation. The data collection techniques used were *tests*, validation, and response questionnaire. The data collection instrument used were the validation sheet, teacher response questionnaire, student response questionnaire, pretest, and posttest. The data analysis technique used is validation, practical, and effective. The average validation Syllabus was 100% and 97,41% of which are very valid criteria. And for the average validation of Learning Implementation Plan (LIP) was 100% and 97,73% which are very valid criteria. The average validation of Students Worksheets (SW) was 100% and 90,02% which are very valid criteria. The average teacher response questionnaire of LIP was 96,42% which is very practiced and the intermediate student's response questionnaire of SW was 86,91% which is very practice. The average of N-Gain score was 80% which is effective. Based on the results it can be concluded that the development of mathematical learning devices with PBL models assisted by Geogebra to enhance student's understanding mathematical concept has produced mathematics learning devices which valid, practical, and effective. So that the learning device is feasible to use.

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1. INTRODUCTION

Education is an important part of human life with other living creatures. According to Nurhuda, (2015). Education is an effort to develop the human potential of students, both physical potential, creative potential, taste, and intention so that this potential becomes real and can function in the course of life. In the Indonesian education curriculum, one of the subjects that must be taught at the elementary, middle, and high levels and in higher education is mathematics. Mathematics is a basic science that underlies the development of other disciplines. However, in its development, mathematics cannot be separated from other sciences which use mathematics as a tool to achieve its development. The purpose of learning mathematics as stated by Permendiknas Number 22 of 2006 is that students can understand mathematical concepts, explain the interrelationships between concepts and apply concepts or algorithms in a flexible, accurate, efficient, and precise manner in problem-solving.

Concept understanding ability is the most important part of learning mathematics (Herawati, Siroj, & Basir, 2013; Nurdin et al., 2019; Purwanti, Pratiwi, & Rinaldi, 2016; Suraji, Maimunah, & Saragih, 2018). Concept understanding is the ability of students to master several subject matter, where students not only know several concepts being studied but can express them again in other forms that are easy to understand (Septiadi & Wahidah, 2022). Concept understanding is the basis of understanding principles and theories, which means that before understanding principles and theories, student's must first understand the applicable concepts (Diana, Marethi, & Pamungkas, 2020; Herawati et al., 2013). The importance of understanding mathematical concepts is not in line with the quality of the ability to understand real mathematical concepts. The facts on the ground show that the mathematics achievement of Indonesian students is still relatively low. It was proven in the 2018 PISA (Programme Internationale for Student Assessment) survey, especially for the mathematics category, Indonesia was ranked 73 out of 80 participants who took part in this program with an average score of 379 when compared to China which was ranked first with an average score of 591 (Sri Ayu Wulaningsih, Sumarni, & Riyadi, 2021).

The 2015 Trends International Mathematics and Science Study (TIMSS) survey also showed the same results, the average math achievement score of Indonesian students was only ranked 44 out of 49 participating countries and the average score obtained was 397, far below the international average of 550. This indicates that students' mathematical abilities in Indonesia are still weak. In addition, based on the results of an interview with one of the mathematics teachers, it was concluded that students were less able to solve problems that were different from the examples, students tended to memorize formulas, and often forgot the material that had been previously studied. In addition, based on research conducted by (Novitasari, 2016) that one of the causes of failure in mathematics learning is that student's do not understand or misunderstand mathematical concepts. The low ability of students to understand mathematical concepts can be caused by several factors, both internal and external factors. One of the external factors comes from outside the students, such as the use of learning methods or strategies contained in the learning device.

Learning tools are a teacher's guide in carrying out learning and at the same time become a benchmark for the implementation of learning (Angraini, Wahyuni, Wahyuni, Dahlia, & Abdurrahman, 2021). Further, according to Ariawan & Putri, (2020) learning tools are tools that can be used by teachers and students in the teaching and learning process. Learning tools can include syllabus, lesson plans, and SW. The results of the researcher's interview with one of the mathematics teachers at the school stated that there were several problems regarding the learning tools, namely; 1) learning tools such as syllabus and lesson plans already refer to the K13 format. However, the lesson plans use one sheet so it is not clear how the learning process is carried out, and the material section also does not contain facts, concepts, principles, and procedures. 2) LIP with the help of GeoGebra software technology has never been found in the school. 3) The available SW only contains a summary of the material and practice questions without any completion guide. 4) The existing worksheets are only available in a few materials and are rarely used because they don't have time and it takes too much time to do them. 5) SW with the help of

GeoGebra has never been found in the school.

Based on the above problems regarding learning devices that have not been able to facilitate students' understanding of mathematical concepts. So it is necessary to have a suitable learning model in helping students understand mathematical concepts. One alternative learning model used is the Problem Based Learning (PBL) model. Febriyanto et al., (2018) stated that the problem-based learning model is a learning model that uses real problems as a context for students to learn about critical thinking and problem-solving skills, as well as acquire knowledge and concepts that are essential from the subject. Problem Based Learning is a learning model that challenges students to "learn how to learn", by working in groups to find solutions to real-world problems (Ariawan & Putri, 2020). The advantages of the PBL model are that it can make learning more meaningful, make students become independent students, and can help students develop their ideas so that student's understanding of concepts will also increase (Sinaga, Purba, Telaumbanua, & Simanjuntak, 2021). In addition, Problem Based Learning can also play an active role in improving learning outcomes, and understanding the concepts and attitudes of students (Zetriuslita; Andrian, 2020).

Although the PBL model can help facilitate students' understanding of mathematical concepts, it is not very significant. Therefore, it is necessary to change and improve by using innovative media as a learning resource, namely the use of GeoGebra software. Geogebra is open software under the GNU (General Public License) and can be found at www.GeoGebra.org (Hohenwarter, 2008). Geogebra is a dynamic mathematics software that can be used as a mathematics learning aid (Isman, 2016; Yanti et al., 2019; Zetriuslita et al., 2020). By learning PBL models assisted by computer technology, learning will involve active students optimally, allowing students to explore various mathematical concepts, and increasing creativity so that they can integrate thinking skills that can help students understand material concepts by themselves (Aufa, Zubainur, & Munzir, 2021). Furthermore, Geogebra is software for visualizing and demonstrating mathematical concepts, especially geometry and algebra (Nur'aini et al., 2017; Yanti et al., 2019; Zetriuslita et al., 2020).

The advantages of using Geogebra software in learning mathematics are: (1) it can produce geometric paintings quickly and accurately, even complex ones, (2) there are animation facilities and manipulation movements that can provide a visual experience in understanding geometric concepts, (3) can be used as feedback/evaluation material to ensure that the geometric painting that has been made is indeed correct, (4) makes it easier to investigate or show the properties that apply to a geometric object. Furthermore, Geogebra is software that allows users to create simple representations of mathematical objects, making it easier for users to find, solve and create mathematical representations of ideas that they already have (Zetriuslita, Istikomah, & Nofriandi, 2021). Therefore, the use of GeoGebra can help facilitate the understanding of mathematical concepts because it is suitable for the application of indicators of understanding mathematical concepts, one of which is presenting concepts in the form of other mathematical representations such as graphs, tables, etc.

This is supported by the results of research conducted by Wahyuni & Rahmadhani, (2020) shows that learning mathematics using the model Assisted PBL geogebra more interesting than the PBL model without the help of GeoGebra media on the ability to understand students' mathematical concepts. The use of GeoGebra software is compatible with one of the materials to be studied in this study, namely linear programming material. The reason the researcher chooses linear programming material is that linear programming material emphasizes and focuses on an optimum value that can be quickly and correctly demonstrated with GeoGebra software. In addition, the linear program is suitable for the application of indicators of the ability to understand mathematical concepts that can be facilitated by PBL models and GeoGebra software. This is reinforced by research by Dewi et al., (2020) who said that based on the results of student learning tests and student response questionnaires that expressed pleasure in using GeoGebra-assisted learning tools, therefore learning using GeoGebra was proven to improve students' conceptual understanding and student motivation.

Based on this, the researcher intends to conduct research by developing a mathematics learning device using the PBL model assisted by GeoGebra software to enhance the ability to understand students' mathematical concepts on the subject of linear program with the title "Development of Mathematics Learning Devices with Problem Based Learning Models Assisted by Geogebra to Enhance Student's Understanding of Mathematical Concept ".

2. METHOD

Method of research used Research and Development (R and D) and the development model design used the ADDIE model with stages are: 1) Analysis, 2) Design, 3) Development, 4) Implementation and 5) Evaluation. The object of this research is learning tools in the form of syllabus, lesson plans, and student worksheets. This research was conducted one SMAN 1 at Bangkinang Kota in the odd semester of the 2022/2023 academic year on the subjects of linear program.

The development model used is the ADDIE model which has 5 stages, namely the analysis stage, the design stage, the development stage, the implementation stage, and the evaluation stage (Sugiyono, 2017b).

This stage begins with analysis; in the analysis phase, the activities carried out are: 1) problem analysis, namely: analyzing the problems contained in the learning tools such as the syllabus, the lesson plan (LIP), the existing Student Worksheet (SW). 2) needs analysis, namely: (a) analyzing the applicable curriculum; (b) analyzing core competencies and basic competencies in linear programming materials; (c) compiling indicators of competency achievement. Design stage; in this design stage the activities carried out are: 1) designing learning tools in the form of syllabus, lesson plans, and SW. 2) designing and making learning device validation sheets, teacher and student response questionnaires, and making test questions in the form of pretest and posttest.

Stage of development; In this stage, the activities carried out are developing learning tools that have been designed in the previous stage. The tools developed are made as attractive as possible and arranged in a good and correct writing format. Furthermore, at this stage validation is carried out. Validation was carried out by 3 validators, namely 2 lecturers of mathematics education at FKIP UIR and 1 teacher of mathematics. After the learning tool is validated by the validator, the researcher makes improvements or revisions according to suggestions and comments, and the product is analyzed whether it is worth trying out or not.

Implementation phase; in this stage, the activities carried out are: 1) using learning tools that have been validated by product trials to schools. The learning tools that were tested were aimed at seeing their practicality and effectiveness. 2) carry out the learning process under the learning tools that have been developed. 3) filling out the teacher response questionnaire sheet to the lesson plan and students to the SW regarding the learning tools that have been used. 4) conduct tests in the form of pretest and posttest to see the effectiveness of the learning tools developed. Evaluation stage; in this stage, the activities carried out are (1) collecting data obtained in the previous stage including validation data from 3 validators, questionnaire data on teacher responses to lesson plans and student response questionnaires on SW, and data on pretest and posttest results for each student. (2) analyze the data that has been obtained to see all the stages carried out. (Sugiyono, 2017a)

Furthermore, the data collected in this study is quantitative. Quantitative data was obtained from the results of the validation sheet, a questionnaire sheet that was analyzed using descriptive statistics. The validity of the learning device is calculated using the following formula (Akbar, 2013).

$$V_{ax} = \frac{TSe}{TSh} \times 100\%$$

Information:

Tse : Total empirical score
Tsh : Total expected maximum score
Va : Expert validator with x = 1,2,3,4

To get the final result of the validity of the validators, can be calculated using the following formula:

$$V = \frac{V_{a1} + V_{a2} + V_{a3} + V_{a4}}{4}$$

After obtaining the results of the combined validity analysis, the percentage level can be adjusted according to the table of validity criteria according to (Akbar, 2013) are revised as follows:

Table 1. Validation Criteria

Score (%)	Validity Level
$85 < P \leq 100$	Very valid or can be used without revision
$70 < P \leq 85$	Sufficiently valid or usable but needs minor revision
$50 < P \leq 70$	Invalid, it is recommended not to use
$01 < P \leq 50$	Invalid, or should not be used

The practicality of learning devices is calculated using the following formula: (Riduwan, 2013)

$$P = \frac{\sum f}{N} \times 100\%$$

The results obtained are interpreted using the criteria according to the modification Riduwan, (2013) as in the following table:

Table 2. Practical Criteria

Score (%)	Validity Level
$80 < P \leq 100$	Very Practical
$60 < P \leq 80$	Practical
$40 < P \leq 60$	Practical enough
$20 < P \leq 40$	Less Practical
$0 < P \leq 20$	Not Practical

The effectiveness of learning devices is calculated using the N-gain score formula (Jusmawati, Upu, & Darwis, 2015) as follows:

$$n\text{-}gain = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

Calculation of n-gain analysis data using normalized gain developed by Meltzer (Simarmata & Sirait, 2020) as follows:

Table 3. Criteria for Normalized N-Gain Score

Gain Increase Criteria	Normalized Score
Tall	$0,7 < g \leq 1,0$
Currently	$0,3 < g \leq 0,7$
Low	$g \leq 0,3$

Meanwhile, the division of n-gain acquisition categories in the form (%) was developed by Hake (Simarmata & Sirait, 2020) is as follows:

Table 4. Category of N-gain Effectiveness Interpretation

Percentage *(P)*	Category Criteria
$\boldsymbol{P} < 40$	Ineffective
$40 < \boldsymbol{P} \leq 55$	Less effective
$56 < \boldsymbol{P} \leq 75$	Effective enough
$\boldsymbol{P} > 75$	Effective

3. RESULTS AND DISCUSSION

1. Syllabus validation results

From the results of the syllabus validation based on aspects, the highest score was found in the completeness aspect of the syllabus components, aspects of learning materials, aspects of assessment, aspects of learning resources, and aspects of language with a score of 100% in the very valid category. While the lowest score is in the aspect of time allocation with a score of 83.33% valid category.

Table 5. Syllabus Components Validation Results for Each Validator

Percentage Validity (%)			Average Validity (%)	Validity Level
V1	V2	V3		
100	100	100	100	Very Valid
Total Average (%)			100	Very Valid

Table 6. IPK, learning materials, learning activities, assessment, time allocation, learning resources, and language Aspects Validation Results of Each Validator

Percentage Validity (%)			Average Validity (%)	Validity Level
V1	V2	V3		
92.85	96.42	95.82	95.03	Very Valid
Total Average (%)			95.03	Very Valid

From the table above, the syllabus validation results of each validator for aspect one are 100% with a very valid category, and aspects two to eight are 95.03% with a very valid category.

2. LIP Validation Results

From the results of LIP validation based on each aspect, the highest score was found in the aspects of the completeness of the LIP components, the formulation of the IPK, the formulation of learning objectives, the formulation of learning materials, and time allocation with an average score of 100% in the very valid category. While the lowest score is in the language aspect with an average score of 88.89% very valid category.

Table 7. The Completeness of LIP Components Validation Results for Each Validator

LIP	Percentage Validity (%)			Average Validity (%)	Validity Level
	V1	V2	V3		
LIP-1	100	100	100	100	Very Valid
LIP-2	100	100	100	100	Very Valid
LIP-3	100	100	100	100	Very Valid
Total Average (%)				100	Very Valid

Table 8. The Formulation of IPK, Learning Objectives, Learning Materials, Learning Resources And Tools, Learning Activities, Assessment, Language, Time Allocation Aspects Validation Results for Each Validator

LIP	Percentage Validity (%)			Average Validity (%)	Validity Level
	V1	V2	V3		
LIP-1	96.25	96.77	97.70	96.90	Very Valid
LIP-2	100	96.77	97.70	98.15	Very Valid
LIP-3	100	96.77	97.70	98.15	Very Valid
Total Average (%)				97.73	Very Valid

From the table above, the results of LIP validation for each validator for aspect one are 100% with a very valid category, and aspects two to nine are 97.73% with a very valid category.

3. SW Validation Results

From the results of the SW validation based on each aspect, the highest score was found in the completeness aspect of the SW component with an average score of 100% in the very valid category. while the lowest score is in the aspect of conformity of learning activities with the quality of the SW and the suitability aspect of the SW with an average score of 83.33% valid category.

Table 9. The Completeness Aspects of SW Component Validation Results for Each Validator

SW	Percentage Validity (%)			Average Validity (%)	Validity Level
	V1	V2	V3		
SW-1	100	100	100	100	Very Valid
SW-2	100	100	100	100	Very Valid
SW-3	100	100	100	100	Very Valid
Total Average (%)				100	Very Valid

Table 10. The Suitability of Learning Materials, Learning Activities, Learning Steps of the SW, IPK of the SW, Contruction, and Technical Aspects Validation Results for Each Validator

SW	Percentage Validity (%)			Average Validity (%)	Validity Level
	V1	V2	V3		
SW-1	92.82	84.72	90.06	89.21	Very Valid
SW-2	92.82	84.72	90.06	89.21	Very Valid
SW-3	92.82	84.72	90.06	89.21	Very Valid
Total Average (%)				89.21	Very Valid

From the table above, the results of SW validation for each validator for aspect one are 100% with a very valid category, and aspects two to four are 97.73% with a very valid category.

4. Teachers Response Questionnaire Result

From the results of the questionnaire analysis of teacher responses to lesson plans based on each indicator, the highest scores were found in indicators 1, 2, 5, 6, and 7 with an average score of

100% in the very practical category. While the lowest score is in indicator 4 with an average score of 83.33% in the practical category.

Table 11. Results of Questionnaire Analysis of Teacher Response to LIP

Percentage Validity (%)			**Average Validity (%)**	**Validity Level**
Pert-1	**Pert-2**	**Pert-3**		
96.42	96.42	96.42	96.42%	Very Practical
Total Average (%)			96.42%	Very Practical

From the table above, the results of the questionnaire analysis of the teacher's response to the lesson plan for each meeting are 96.42% with a very practical category.

5. Student Response Questionnaire Result

From the results of the questionnaire analysis of student responses to SW based on each indicator, the highest score is found in indicator 9 with an average score of 90.40% very practical category. While the lowest score is in indicator 2 with an average score of 83.98% in the very practical category.

Table 11. Results of Questionnaire Analysis of Student Responses to SW

Percentage Validity (%)			**Average Validity (%)**	**Validity Level**
Pert-1	**Pert-2**	**Pert-3**		
85.26	86.16	89.34	86.92	Very Practical
Total Average (%)			86.92%	Very Practical

From the table above, the results of the questionnaire analysis of student responses to SW each meeting are 86.92% with a very practical category.

6. Effectiveness Result

The results of the pretest and posttest analysis are obtained that average test results the effectiveness of learning devices shows the value of the N-Gain score of 79% in the Effective category. The highest score on the pretest is 67 and score the lowest is 13. Then, the highest posttest score is 100 and score the lowest is 80. So that learning tools have been developed the researcher obtained a high category and was able to improve student learning outcomes and can facilitate abilities understanding of students' mathematical concepts in Linear Program material

Linear Program learning is designed to develop learning tools such as Syllabus, LIP and SW in this study. The development model utilized is ADDIE model with 5-stages. The following is an explanation of the five steps. First, consider the front-end analysis: At first step, the challenges encountered by mathematics teachers at SMA N 1 Bangkinang, particularly class XI mathematics teachers, were identified. According to the findings of this preliminary investigation, the learning process in the classroom is still concentrated on the teacher. On the other hand, because textbooks are the only instructional materials offered by the school, most pupils engage in unrelated activities during the learning process. It demonstrates that the teacher employs one of the ready-to-use learning tools rather than learning material. The teacher didn't used Geogebra software, especially for linear program subject. It shows that it is necessary to develop teaching of mathematics learning devices with problem based learning models assisted by geogebra to enhance student's understanding of mathematical concept. GeoGebra classrooms that had never been used in the learning process, despite the fact that the use of mathematical software as a catalyst will have several positive impacts, including work that is more effective, precise, and efficient (Nur'aini et al., 2017).

The second stage, At this stage, learning tools are designed that will be developed in the form of a syllabus, LIP and SW with the Geogebra-supported PBL model which can facilitate students' understanding of concepts in linear program material. The steps taken were: a) designing learning tools in the form of a syllabus that refers to the 2013 curriculum by implementing Geogebra-assisted PBL, b) designing learning tools in the form of LIP and SW that refer to the 2013 curriculum by implementing Geogebra-assisted PBL.

The third stage, at this stage what done is: 1) completing the syllabus components that have been designed in the previous stage, 2) making devices according to existing rules, 3) Devices that have been made are then validated by material experts and Geogebra experts. The fourth stage, implementation stage, at this stage what done is: After the learning device has been validated by the experts, it is then tested on students through three meetings. From the results of this trial, the practicality and effectiveness of the developed device were obtained. The last stage, evaluation stage, at this stage, an evaluation of the validation results, the results of the learning device trials were carried out. From the results of the validation, revisions were made according to the validator's suggestions and the test results obtained the results of the practicality and effectiveness of the learning device. The result is that learning tools in the form of syllabus, LIP and SW categories are valid, very practical and effective.

According to (Harahap, Sinaga, & Siagian, 2021) it can be concluded that the average LIP validation result is 4.51 and the average SW validation is 4.22 which has met the valid criteria. For the practicality of learning devices, it is seen from the implementation of learning with an average of 81.67% in the first experiment and 87.22% in the second trial with a good category. To see the effectiveness in terms of classical student learning completion, it has reached 87.5% in experiment II with an effective category.

Then, the research conducted by (Asmiati, Ikhsan, & Subianto, 2020) can be concluded that the average result of LIP validity is 3.8 and the average SW validation is 3.77 which indicates valid criteria. To see the practicality of learning devices obtained from the teacher response questionnaire with an average total of 3.8 which showed excellent criteria and used learning implementation sheets with an average total of 4.76 with excellent criteria.

This proves that the development of learning devices has been tested for validity, practicality, and effectiveness. Previous research revealed no research on designing learning aids that include PBL into GeoGebra classes to improve visual thinking and subject of research another previously research at SMP . So this development research using PBL with GeoGebra to enhance student's understanding of mathematical concept at SMA is brand new.

4. CONCLUSION

Based on the results of research data analysis, it can be concluded that mathematics learning tools have been produced in the form of Syllabus, Learning Implementation Plans (LIP), and Student Worksheets (SW) with Problem Based Learning (PBL) models assisted by Geogebra to enhance understanding of mathematical concepts in linear program subjects which has been tested for validity with very valid results, practicality with very practical results, and effectiveness with effective results. So that the learning tools developed are feasible to use.

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