

## Development of the Design of Mathematical Learning Material Maximum and Minimum Derivative Based on Van Hiele Theory with the Assistance of Geogebra

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### Abstract

This study aims to produce mathematics learning tools for maximum and minimum value material based on van Hiele's theory with the help of Geogebra and to determine the quality of learning tools based on validity, practicality and effectiveness. The development model used is the Generic EDR model by Mckenney and Reeves with five stages, namely (1) analysis-exploration, (2) design-construction, (3) evaluation-reflection, (4) preparation of theoretical interpretation-intervention and (5) implementation. The results showed that the average RPP validation score was 4.46, the average LKPD validation score was 4.23, and the THB validation average score was 4.46, with a very good category that met the valid criteria. The teacher and student response questionnaire results, show an average value of 4.33 and 4.29, indicating that the design of learning devices is categorized as very practical. Moreover, the percentage of student learning outcomes test completeness is 90.32. This shows that the design of learning devices is categorized as very effective. Therefore, based on the trial results, the learning device designs developed meet valid, practical and effective criteria.

**Keywords:** Learning Devices, Van Hiele Theory, Geogebra, Derivatives.

### Abstrak

Penelitian ini bertujuan untuk menghasilkan perangkat pembelajaran matematika materi nilai maksimum dan minimum berbasis teori van hiele berbantuan geogebra dan untuk mengetahui kualitas perangkat pembelajaran berdasarkan aspek kevalidan, kepraktisan dan keefektifan. Model pengembangan yang digunakan adalah model Generik EDR karya Mckenney dan Reeves dengan lima tahapan yaitu (1) analisis-eksplorasi, (2) desain-konstruksi, (3) evaluasi-refleksi, (4) pematangan intervensi-pemaknaan teoritik dan (5) implementasi. Hasil penelitian menunjukkan bahwa rata-rata skor nilai validasi RPP 4,46, rata-rata skor nilai validasi LKPD 4,23, dan rata-rata skor nilai validasi THB 4,46 dengan kategori sangat baik dan memenuhi kriteria valid. Hasil angket respon guru dan peserta didik menunjukkan nilai rata-rata 4,33 dan 4,29 sehingga menunjukkan bahwa desain perangkat pembelajaran dikategorikan sangat praktis. Dan persentase ketuntasan tes hasil belajar siswa adalah 90,32. Hal ini menunjukkan bahwa desain perangkat pembelajaran dikategorikan sangat efektif. Oleh karena itu, berdasarkan hasil uji coba dapat disimpulkan desain perangkat pembelajaran yang dikembangkan memenuhi kriteria valid, praktis dan efektif.

**Kata Kunci:** Perangkat Pembelajaran, Teori Van Hiele, Geogebra, Turunan

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## INTRODUCTION

Mathematics is one of the lessons that has a big role in education. Permendiknas No. 22 of 2006 concerning Content Standards states that one of the objectives of learning mathematics at all levels of primary and secondary education is for students to solve problems which include the ability to understand problems, design mathematical models, complete models, and interpret solutions obtained (Mangelep, 2017; Domu et al., 2023). Mathematics is one of the important subjects given at all levels of education, starting from basic education to higher education, to equip students to improve their ability to think logically, analytically, systematically, critically, and creatively, as well as the ability to

work together (Sundayana, 2015; Mangelep, 2017). One of the subjects in learning mathematics is the maximum and minimum values, especially those related to the application of algebraic function derivatives taught to class XI high school students.

Based on the results of the researcher's interview with a mathematics teacher at SMA Negeri 1 Langowan, it is known that in teaching and learning activities in class, the understanding of the concept of maximum and minimum values needs to be addressed by students. This is because students have difficulty imagining material statements delivered by the teacher. Therefore, students tend to memorize concepts rather than understand the meaning of existing concepts. This can be seen from the results of the initial tests given by the researchers to 30 students in class XI MIPA SMA Negeri 1 Langowan. Based on the initial test, only 15 students scored above the KKM. While the Minimum Completeness Criteria (KKM) for mathematics at SMA Negeri 1 Langowan is 75.

Based on the results of the researcher's interviews with several class XII students of SMA Negeri 1 Langowan who had studied the maximum and minimum scores, it was said that this material took much work to understand. Students need help determining the first derivative of a function and understanding why the maximum and minimum values can occur at the endpoints, stationary points, or singular points of a function. The teacher has delivered explanations regarding the material, but only limited to verbal explanations or using blackboard media, books, and PowerPoint. Learning by using graphics is the easiest way to understand the concept of maximum and minimum values. However, the lack of media that supports students to explore at school makes it difficult for teachers to provide understanding in this way.

One solution to students' difficulties in understanding the concept of maximum and minimum values is using information technology-based learning media. GeoGebra is open-source software that can be used as a learning resource or media (Mangelep, 2013; Ramlan, 2020). Geogebra was developed by Markus Hohenwarter in 2001. GeoGebra is a dynamic program with facilities for visualizing or demonstrating mathematical concepts and tools for constructing mathematical concepts (Mangelep, 2015; Walid, 2017). Using Geogebra can produce a maximum and minimum value learning tool to help students better understand the concepts in the maximum and minimum value material (Mangelep et al., 2020). Learning tools are designed here as lesson plans, worksheets, and student learning outcomes tests, compiled based on needs analysis and identification of problems with learning material derived from maximum and minimum values (Tiwow et al., 2023).

The learning approach used in designing learning tools plays an important role in developing learning tools. A series of learning activities that can impart knowledge, such as reinventing a general concept or form, should increase students' conceptual understanding. Learning based on van Hiele's thinking stages is one of the learning theories that emphasize the things above. According to Abdussakir (2009), Van Hiele's theory, which was developed around 1950 by Pierre Marie Van Hiele and Dina Van Hiele-Geldof, has been recognized internationally and has had a strong influence on learning geometry in schools. According to Van Hiele (Nurani et al., 2016; Tiwow et al., 2023),

students' thinking stages in learning geometry from a certain stage can be increased to the next depending on learning. This means that to reach a higher level of thinking. One must go through the previous level of thinking (Sukayasa et al., 2022; Runtu et al., 2023) and (Sahara & Nurfauziah, 2021; Rompas et al., 2023). Van Hiele (Bautista & Valtoribio, 2016; Kambey & Mangelep., 2019) develops a theory of levels/levels of geometric thinking. There are five levels/levels of thinking in understanding geometry, namely level (0) Visualization, level (1) Analysis, level (2) Informal Deduction, level (3) Deduction and level (4) Rigor. The advantages of van Hiele's theory are (1) the stages are hierarchical and sequential, (2) the speed of moving from one stage to the next depends on learning, and (3) each stage has its own vocabulary and relational system. (Anne, 1999; Domu et al., 2023).

## **METHOD**

The type of research in this research is development research to develop mathematics learning tools. The method used in this study is developing the EDR (Educational Design Research) type using the Generic EDR model (McKenney & Reeves, 2012). Research and development activities with the generic EDR model are divided into five stages: analysis, design, evaluation, intervention and knowledge, and implementation.

The subjects in this study were students of class XI MIPA at SMA N 1 Langowan in the odd semester of the 2022/2023 academic year. The research subjects in small group trials were conducted on students in class XI MIPA 2 consisting of 9 people consisting of 3 high-ability students each, 3 medium-ability students and 3 low-ability students, while the research subjects were in the test large group tryout was conducted on students of class XI MIPA 3.

Data collection techniques used in this study were: interviews, expert validation, questionnaires and learning achievement tests. The data analysis technique used is the descriptive analysis technique. The data analyzed include qualitative data and quantitative data. Qualitative data analyzed in this study included data from interviews with teachers, evaluation of product development guidelines and data on product validation suggestions. The quantitative data analyzed was in the form of closed questionnaire results, which included the feasibility of the learning design from the validator and responses from teachers and students as test subjects.

## **RESULT AND DISCUSSION**

The research results from the section; discuss the development of learning device designs. The method used in this research is developing the EDR (Educational Design Research) type using the Generic EDR model (McKenney & Reeves, 2012). Generic model research and development activities are divided into five stages: analysis, design, evaluation and intervention and knowledge, and implementation. The development steps are as follows:

## 1. Analysis-Exploration Stage

Researchers identify problems to obtain information and analyze problems in the field through preliminary studies conducted through pre-tests on students, analysis of needs through interviews with teachers and students, and analysis of the school curriculum. Based on the results of the initial test given by the researcher to class XI MIPA students, where the test in the form of a description item determines the maximum and minimum scores, the results of 30 students are only half of the total number of students who meet the Minimum Completeness Criteria of 75. Based on the results of interviews researchers with teachers and students, it can be concluded that: (1) The process of learning activities carried out by the teacher is carried out orally or by using whiteboards, books, and PowerPoint, (2) Learning activities require teachers and students to use electronic media, but the use of learning media is still lacking, (3) It is known that in teaching and learning activities in class students' understanding of the concept of maximum and minimum scores is often ignored by students. This is because students need help imagining material statements conveyed by the teacher, (4) Material derived from maximum and minimum values is very difficult for students to understand. Based on the results of curriculum analysis, the curriculum used in SMA Negeri 1 Langowan is the 2013 curriculum. In this study, the maximum and minimum value materials were chosen because most students had difficulty learning them; the student's difficulties in learning the maximum and minimum value materials were caused when looking for the maximum and minimum grades. At a minimum, you must first find the first derivative of a function, and students often need to remember the formula for finding the first derivative of a function. Hence, students need to understand the concept to memorize the formula.

## 2. Design-Construction Stage

At the design stage, the researcher designed the Geogebra program to be used by students, then designed learning tools in the form of Learning Implementation Plans (RPP), Student Worksheets (LKPD) and Learning Outcomes Tests (THB). The RPP, LKPD and THB learning tools are combined with van Hiele's theory with the help of Geogebra. The validation results of RPP, LKPD and THB carried out by the validator can be stated in the following table.

Table 1. RPP Validation Results

Aspect	Validator			Average Score	Category
	V1	V2	V3		
Material	4,00	4,00	5,00	4,33	Very Good
Construction	4,40	4,00	4,80	4,40	Very Good
Language	5,00	4,50	4,50	4,66	Very Good
<b>Conclusion</b>				4,46	Very Good

Table 2. LKPD Validation Results

Aspect	Validator			Average Score	Category
	V1	V2	V3		
Material	4,00	3,66	5,00	4,22	Very Good

Construction	4,00	3,50	5,00	4,16	Good
Language	4,50	4,00	4,50	4,33	Very Good
<b>Conclusion</b>				<b>4,23</b>	<b>Very Good</b>

Tabel 3. THB Validation Results

Aspect	Validator			Average Score	Category
	V1	V2	V3		
Material	4,00	4,00	5,00	4,33	Very Good
Construction	4,66	4,00	5,00	4,55	Very Good
Language	4,50	4,50	4,50	4,50	Very Good
<b>Conclusion</b>				<b>4,46</b>	<b>Very Good</b>

## Discussion

### 1. Evaluation-Reflection Stage

At the evaluation stage, the researcher conducted trials on learning device products that had been validated and product assessments to be evaluated. The try-out was carried out in small groups of 9 people with the criteria of 3 people with low abilities, 3 with moderate abilities and 3 with high abilities on October 20, 2022. The results of the implementation of learning and students' responses to the implementation of learning (1) Overall, the test tried small groups according to the plan made by the researcher, (2) the implementation of learning using the van Hiele theory learning device design went well, (3) the learning process using worksheets makes it easy for students to understand the material, (4) learning uses worksheets, students feel motivated to learn the material contained in the LKPD. They will try to understand the material by asking the teacher if there is unclear material. (5) Students can use GeoGebra easily.

### 2. Intervention-Theoretical Meaning Maturation Stage

Based on the weaknesses in the small group trial, during the intervention maturation stage, the researcher will revise or improve the productivity of the mathematics learning material on the maximum and minimum value based on van Hiele's theory assisted by Geogebra, which was developed according to the trial results. Revisions were made to the components of the learning device, namely in terms of improved material, namely simplifying concepts that were difficult to apply and adding to the exposure of theoretical material. Regarding language, fix sentences that are less communicative and writing errors.

### 3. Implementation Stage

The researcher conducted a field test of the revised learning device product at the implementation stage. The trial was carried out in a large group, namely class XI MIPA 3 students at SMA Negeri 1 Langowan consisting of 31 students on October 25 2022. This trial was conducted to confirm the data and determine students' responses to the product broadly. The learning outcomes test was carried out on October 31, 2022. The data obtained from the student learning outcomes test for class XI MIPA 3 consisted of 31 students, 3 of whom did not meet the KKM, namely 75. The highest

score was 100, the lowest score was 72, with an average class of 84, and the percentage of student learning achievement tests was 90.32. This shows that the design of learning devices is categorized as very effective.

Table 4. Results of the learning outcomes test assessment

Variation	Data Trial Class
Highest Score	100
Lowest Score	72
Average	84
Many Students complete the study	28
Many students do not complete learning	3
<b>Percentage of completeness</b>	<b>90,32</b>

After carrying out the learning outcomes test, the students completed the student response questionnaire, distributed via the Google form. Furthermore, researchers also distributed response questionnaires to teachers. The average score obtained from teacher responses was 4.33, and the average score obtained from student responses was 4.29. Based on the teacher and student response questionnaire's practicality category, the learning device's design is categorized as Very Practical.

Table 5. Results of Teacher Response Questionnaire Assessment

Aspects assessed	Average Score
Usefulness	4
Ease of use	5
Help improve students understanding	4
<b>The average score</b>	<b>4,33</b>

Table 6. Results of the student response questionnaire assessment

Aspects assessed	Average Score
Usefulness	4,43
Ease of use	4,36
Help improve students understanding	4,54
<b>The average score</b>	<b>4,29</b>

The results showed that the learning tools developed in this study consisted of Learning Implementation Plans (RPP), Student Worksheets (LKPD), and Learning Outcomes Tests (THB), which were valid, practical, and effective.

#### 4. Results of Validity Analysis

##### a. Validation of Learning Implementation Plans

Based on the validation of the Learning Implementation Plan, the average results for each aspect are obtained. Material aspects get 4.33 with Very Good qualifications. This shows that the designed Learning Implementation Plan is clear with basic competencies, the suitability of basic competencies and learning objectives, and the accuracy of translating basic

competencies into indicators. The construction aspect is 4.40 with a Very Good qualification. Based on this, the presentation of the RPP follows the characteristics and systematics of preparation. Furthermore, the language aspect gets 4.66 with a Very Good qualification. This shows that the language used follows Indonesian rules and is easily understood by students. Based on the categories obtained from each assessment aspect, overall, the RPP obtains an average score of 4.46 in the Very Good category

b. Student Worksheet Validation

Based on the validation of Student Worksheets, the average results are obtained from each aspect. Material aspects get 4.22 with Very Good qualifications. This shows that the LKPD designed the material covered according to the learning objectives, also following the existing concepts, and the scope of the material in the LKPD follows the level of student knowledge. The construction aspect obtained 4.16 with a Good qualification. Based on this, the presentation of LKPD presents material assisted by GeoGebra and LKPD containing elements of titles, identities, learning objectives and instructions in learning activities.

Furthermore, the language aspect gets 4.33 with Very Good qualifications. This shows that the accuracy of the language in the LKPD follows the General Guidelines for Indonesian Spelling and the use of sentences that students understand. Based on the categories obtained from each assessment aspect, the overall LKPD obtains an average score of 4.23 in the Very Good category.

c. Learning Outcomes Test Validation

Based on the validation of the Learning Outcomes Test, the average results for each aspect are obtained. Material aspects get 4.33 with Very Good qualifications. This shows that the questions follow basic competencies, learning objectives and the 2013 curriculum. The construction aspect is 4.55 with a Very Good qualification. Based on this, the formulation of the question uses question words and command words that demand answers to student descriptions and problem information on questions that are easy to understand. Furthermore, the language aspect gets 4.50 with a Very Good qualification. This shows that the accuracy of the language used follows the rules of Indonesian, and the sentences used are clear and easy to understand.

Based on the categories obtained from each aspect of the assessment, overall, THB obtained an average score of 4.46 in the Very Good category

5. Practicality Analysis Results

The results of teacher and student responses to learning tools based on the usefulness aspect, the average score of teachers was 4, and students scored 4.43 and were declared Very Practical. This shows that learning based on van Hiele's theory is useful in helping teachers and students learn and delivering material to LKPD can help students understand and use it in Geogebra. Based on ease of

use, the average score of teachers gave a score of 5, and students gave a score of 4.36 and were declared Very Practical. This shows that teachers and students can easily use GeoGebra in learning, and GeoGebra-assisted learning tools are easy to access. Based on the aspect of helping to increase student understanding, the average score of teachers gave a score of 4, and students gave a score of 4.54 which was stated to be Very Practical. This shows that van Hiele's theory-based learning with the help of GeoGebra helps students understand the maximum and minimum value derivative material and can help students in learning. Based on the teacher's response questionnaire results, the average score of the teacher's response was 4.33. The results of the student response questionnaire obtained the average score of the student's responses to be 4.29. Based on the teacher and student response questionnaire's practicality category, the learning device's design is categorized as Very Practical.

## **CONCLUSION**

Based on the results and discussion that has been described, the conclusions obtained from this study are:

1. In this research, the design of mathematics learning tools for material derived from maximum and minimum values has been developed in the form of Learning Implementation Plans (RPP), Student Worksheets (RPP), and Learning Outcomes Tests (THB) based on van hiele theory assisted by GeoGebra carried out with the Geogebra model. Generic EDR development includes 5 stages: analysis-exploration, design-construction, evaluation-reflection, maturation of intervention-theoretical meaning and implementation.
2. The results of developing the design of mathematics learning tools for maximum and minimum grade derivative materials in the form of Learning Implementation Plans (RPP), Student Worksheets (RPP), and Learning Outcomes Tests (THB) based on van Hiele theory assisted by Geogebra are feasible to use in terms of validity aspects seen from the validation of learning tools in the form of Learning Implementation Plans (RPP) obtained an average final score of the assessment results which was 4.46 and categorized as Very Good. The Student Worksheet (LKPD) obtained an average final score of the assessment results, namely 4.23 and was categorized as Very Good. Furthermore, the Learning Outcomes Test (THB) obtained an average final score of 4.46 and was categorized as Very Good. The practicality aspect can be seen from the results of the student response questionnaire obtaining an average score of 4.29. Based on the practicality category of the student response questionnaire shows that the learning device is categorized as Very Practical. Judging from the effectiveness of student learning outcomes tests, the percentage of student learning outcomes test completeness is 90.32. This shows that the learning device is categorized as very effective.

Based on the statement above, the design of the mathematics learning tool for material derived from the maximum and minimum values based on van Hiele's theory with the help of developed Geogebra meets valid, practical, and effective criteria.

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