



Development of Geogebra Learning Media Material on the Relationship Between Coefficients and Discriminants of Quadratic Functions

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ABSTRACT

This study aims to create media products that are suitable for use and make it easier for students to understand the material concept of the relationship between coefficients and discriminants of quadratic functions with their graphs. The media was developed using GeoGebra and student worksheets. This study uses the development of the ADDIE model with the stages of analysis, design, development, implementation, evaluation. The developed media was tested on 29 students of SMP Salahuddin class IX D. The developed media was declared valid based on the validator's assessment with the percentage of validity of interview guidelines 97%, learning media 92%, student worksheets 94%, lesson plans 94%, quizzes 91%, 95% student response questionnaire, 93% student activity observation sheet, 92% teacher activity observation sheet. The media is declared practical based on the teacher's assessment with the percentage of practicality of student response questionnaires 88%, student activity observation sheets 96%, teacher activity observation sheets 96%. The media was also declared effective based on student quiz assessments with a percentage of 93% of students getting an average score of at least 80 completeness requirements the graph.

Keywords: quadratic functions; geogebra; student worksheets; learning media

INTRODUCTION

Learning is a continuous relationship between teachers and students in a learning environment (Maswan and Khoirul Muslimin, 2017:366-367). Learning can be said to be successful if students understand what is being discussed. Therefore, teachers should create a learning structure system that allows students to deepen their understanding of the material being taught. Learning media is used to support the development of learning materials delivered and will also have an impact on problem solving (Zulhenti, 2018:43). Good learning media should not only hone students' skills but also direct students to find their own concepts. One indicator of conceptual understanding is problem solving (Jahro, et al., 2018). If students are only taught to hone their skills through assignments, it will result in students not understanding the relationship between previously discussed material and the material being discussed.

One of the important functions in learning is learning media (Saragih, et al., 2024). The advancement of Information and Communication Technology (ICT) which is interpreted as Information and Communication Technology (ICT) is running by following the development of communication technology. One of these communication technologies is computer networks. The use of ICT in learning can be used as a medium to develop learning materials. According to Erlinawati (2018), computer technology helps teachers conduct learning simulations related to real life in abstract teaching materials.

According to Safitri (2017), the basis for the need to use computer-assisted learning media is reviewed based on the 21st century learning paradigm, the 2013 curriculum is designed to make computer facilities for all subjects in the secondary school curriculum

structure. The use of computer-assisted media makes the process of presenting and delivering learning materials more fun, interesting, and interactive. One of the software that can be used to develop computer-assisted learning materials is GeoGebra classic 5. GeoGebra is an interactive mathematics software capable of dynamically combining graphs, algebra, geometry, and data (Azizah & Anjarwati, 2023). GeoGebra-based teaching materials help students understand abstract concepts more easily, increase learning motivation, and encourage students' geometric engagement and reasoning.

GeoGebra is an acronym for geometry algebra which means algebraic geometry (Agung, 2017). Material that combines the concepts of geometry, calculus, and algebra can combine GeoGebra as a learning medium (Nur, 2016). The creativity and ability of each teacher affect how the results are designed with Geogebra. Teachers must also choose the right approach, method, and learning model. In the material of coefficients and discriminants of quadratic functions, students need to understand how changes in the values of a , b , and c affect the shape of the graph and the value of d affects the number of roots. This process requires dynamic visualization, so GeoGebra-based teaching materials are very helpful in clarifying the relationship between discriminant values and quadratic function graphs.

According to Sagita (2016), teaching materials can be designed in the form of teaching aids, learning media, or various learning resources. Learning resources are devices used during the learning process. Learning resources exist to support the achievement of learning objectives. Various sources of several forms of learning resources that are commonly used during learning are textbooks, modules, videos, audio, images, and student worksheets. The use of media aims to make it easier for students to learn the material and facilitate the learning process (Budiman & Esvigi, 2017).

Darmodjo and Kaligis (in Sagita, 2016: 40-41) state that good student worksheets are those that meet the requirements of learning theory, design, and creation. This means being able to overcome individual student differences, highlight the process of concept discovery, and develop student communication skills. Design requirements are language requirements, sentence formation processes, and clarity that must be adequate so that students can understand the worksheet. There are three technical requirements for creating student worksheets, namely: (1) font type, (2) images, and (3) appearance. The font type used is block letters, avoiding Latin letters, and trying to compare the size of the letters and the size of the image accordingly. A good image to use in a student worksheet is an image that effectively conveys the content or message to students. The appearance of the worksheet is very important because it can attract students' attention. One of the Content Standards for mathematics learning objectives is the objective of mathematics learning so that students can understand the ability to understand a concept in the lessons they have (Permendikbud, 2016). The main function of the teacher is to design, develop, implement, and evaluate learning (Yuwono, et al., 2019). Therefore, the teacher is one of the main elements in determining the success or failure of learning. The development of concepts from quadratic function graphs usually starts from various quadratic functions which will ultimately encourage students to find the concept of the quadratic function graph itself. Based on the results of teacher interviews in mathematics learning at SMP Shalahuddin Malang class IX D for quadratic function material, especially on quadratic function graphs, students still experience obstacles in learning mathematics.

RESEARCH METHODS

This research is a development type of research. This research applies the ADDIE model development study. The stages of the development process contained in this model are Analysis, Design, Develop, Implement, and Evaluate (Sugiyono, 2017). This model is

used because it is suitable for the needs of developing computer-based media and student activity sheets.

The first stage is the analysis stage. The stages of analysis carried out next are divided into 3, namely needs analysis, curriculum analysis, and student characteristics analysis. Needs analysis is carried out to analyze problems that arise in students so that alternative solutions can be sought. Curriculum analysis is carried out to select materials that are in accordance with the current curriculum including basic competencies, indicators, and learning objectives. Analysis of student characteristics is carried out to determine the suitability of the media to be developed with the conditions of students during learning. Researchers obtain information about the three stages of analysis above through interviews with mathematics teachers.

The second stage is the design stage. At this stage, researchers design designs for selecting computer-assisted learning media and selecting student worksheet formats. The researcher used Geogebra Classic 5 for media selection. The researcher also used the guided discovery learning method and the scientific learning approach for selecting the format of the student worksheets. The third stage is the development stage. The results obtained at this stage are the "HAK & NITNA" learning media and student worksheets. Both results obtained will be tested for validity by expert validators and mathematics teachers. The expert validator assessment was carried out by UM mathematics lecturers and SMP Shalahuddin Malang mathematics teachers.

The fourth stage is the implementation stage. This stage will test the subjects for the "HAK & NITNA" learning media and student worksheets whether they meet the practical and effective requirements. The fifth stage is the evaluation stage. This stage will evaluate the results obtained from the quality test of the "HAK & NITNA" learning media and student worksheets that were previously developed in the validity, practicality, and effectiveness tests.

The research was conducted at SMP Shalahuddin Malang with 29 students of class IX D as the test subjects. This research was conducted at the school because students often have difficulty in understanding the material, have never used GeoGebra, and teachers have not developed interactive teaching materials. In this material, students usually learn quadratic function graphs by drawing them one by one, then analyzing the influence of coefficients and discriminants on the shape of the graph. This process is time-consuming and ineffective, so GeoGebra-based teaching materials are needed that can help students visualize changes in graphs dynamically without having to draw them manually. The research data were obtained from the scores on the validation sheet, the scores of the student worksheets, the quiz scores, and the student response questionnaires. The data were analyzed from the media developed based on three requirements, namely, validity, practicality, and effectiveness. The tools used by the researcher in the research include a preliminary study using teacher interviews, to determine the feasibility of the "HAK & NITNA" learning media using a validation sheet, to determine the practicality of the "HAK & NITNA" learning media using a student response questionnaire, student activity observation sheets, and teacher activity observation sheets, to determine the effectiveness of the media material on the relationship between the coefficient and discriminant of the quadratic function with its graph using quiz questions. The data analysis techniques used by the researcher to measure the results of data collection are as follows.

1. Product validity test

The product validity test is obtained from the total score of the validation sheet that has been filled in by the media expert validator and mathematics teacher. The products filled in include interview guidelines, "HAK & NITNA" learning media, student

worksheets, quiz questions, lesson implementation plans, student response questionnaires, student activity observation sheets, and teacher activity observation sheets. The total score evaluated using the Akbar formula (2016) is as follows:

$$V = \frac{Tse}{Tsm} \times 100\%$$

Description:

V = Percentage of validity

Tse = Total empirical score

Tsm = Total maximum score

The results of the validity percentage are then matched with the product validity requirements according to Akbar (2016) which are listed in Table 1.

Table 1. Requirements for Product Validity Test Assessment

| Percentage of Value Achievement Requirements (%) | Validity Level | Description |
|--|----------------|--------------------|
| $85 < V \leq 100$ | Very Valid | No Revision Needed |
| $70 < V \leq 85$ | Valid | Minor Revision |
| $50 < V \leq 70$ | Less Valid | Major Revision |
| $0 < V \leq 50$ | Not Valid | Unusable |

Source: Akbar (2016)

A product can be said to be valid if experts have tested it and every assessment instrument used is appropriate. The results of the product's validity are proven by the assessment of two validators and obtain a validity score (V) of at least 70%.

2. Product practicality test

The product's practicality test is obtained from the total score of the sheet that has been filled in by the user in this case the student. In addition, the practicality test is also obtained from the total score of the teacher's observation sheet for students and teachers (researchers) during the learning process. The total score is obtained from the student response questionnaire sheet that has been filled in by the student, the student activity observation sheet filled in by the teacher, and the teacher activity observation sheet filled in by the teacher. The student response questionnaire sheet contains student assessments regarding the "HAK & NITNA" learning media and student worksheets. The student activity observation sheet contains the teacher's assessment of the sequence of student activities during the learning process. The teacher activity observation sheet contains the teacher's assessment of the sequence of teacher (researcher) activities during the learning process. The total score evaluated using the Akbar (2016) formula is as follows:

$$P = \frac{Tse}{Tsm} \times 100\%$$

Description:

P = Percentage of practicality

Tse = Total empirical score

Tsm = Total maximum score

The results of the validity percentage are then matched with the product practicality requirements according to Akbar (2016) which are listed in Table 2.

Table 2. Product Practicality Test Assessment Requirements

| Percentage of Value Achievement Requirements (%) | Practicality Level | Description |
|--|--------------------|--------------------|
| 85<P≤100 | Very Practical | No Revision Needed |
| 70<P≤85 | Practical | Minor Revision |
| 50<P≤70 | Less Practical | Major Revision |
| 0<P≤50 | Not Practical | Unusable |

Source: Akbar (2016)

A product can be said to be practical if students can use the product easily. The practical results of the product are proven by student assessments and obtain a practicality score (P) of at least 70%.

3. Product effectiveness test

The product effectiveness test is obtained from the total score of the quizzes that students have worked on. The total score evaluated uses the Akbar (2016) formula as follows:

$$E = \frac{x}{S} \times 100\%$$

Description:

E = Percentage of effectiveness

x = Total students who get an average score of at least KKM

S = Total students who are the subjects of the study

A product can be said to be effective in helping students understand the material on the relationship between coefficients and discriminants of quadratic functions with their graphs. The effectiveness of the product is proven by the assessment of student quiz scores and obtaining an effectiveness score (E) of at least 80% with the trial subjects getting a minimum KKM score of 80 (Hobri in Azizah, 2021).

RESULTS AND DISCUSSION

The results of this study are the learning media "HAK & NITNA" and student worksheets. The following is an explanation of the development process of the learning media "HAK & NITNA" and student worksheets using the ADDIE development model.

Analysis Stage

The need for analysis is carried out to analyze the problems that occur in students so that alternative solutions can be found. In the analysis stage, students begin learning by observing the general form of a quadratic function and identifying the values of the coefficients a, b, and c. Next, students analyze how changes in each coefficient affect the shape of the graph, such as the direction of the parabola opening, the axis of symmetry, and the vertex. After that, they explore the discriminant value to determine the number of roots of the quadratic equation. Through this stage, students learn to connect between algebraic forms and graphical representations gradually, until they are able to draw conclusions about the role of coefficients and discriminants independently. From the results of the teacher interviews, information was obtained that students still experience obstacles when studying

quadratic function material, especially in quadratic function graphs. The effectiveness of the media used is quite large because if only lectures or blackboards, students do not understand the material being taught. The majority of students' learning styles are visual or given images or moving directly. Therefore, the researcher developed a learning media for quadratic function graph material assisted by computers with GeoGebra and student worksheets where the media can be used by students independently in the computer laboratory. This is in line with Umairoh's research (2018) which found that there were several obstacles experienced by students in solving quadratic function problems. One of the obstacles faced by students is applying the concept, namely students are not yet skilled in applying the principle of the axis of symmetry and drawing quadratic function graphs on Cartesian diagrams.

Design Stage

After obtaining data in the previous stage, the "HAK & NITNA" learning media and student worksheets are continued at the design stage of the "HAK & NITNA" learning media, student worksheets, and quiz questions. The researcher chose computer-assisted learning media in this case GeoGebra. Then design the media where there are instructions, descriptions, slides, and components obtained based on the quadratic function graph on the right side of the media and the image of the quadratic function graph itself on the left side of the media. The researcher chose student worksheets teaching materials with a scientific approach. Then design the student worksheets structure including: (a) student identity, (b) student worksheets title, (c) class/semester, (d) material, (e) basic competencies, (f) indicators, (g) instructions for use, and (h) student worksheets work stages that are adjusted to learning activities. The researcher compiled quiz questions that were in accordance with the learning objectives to be achieved. The preparation of quiz questions was carried out to determine the effectiveness of the "HAK & NITNA" learning media and student worksheets on the material of quadratic function graphs by looking at the total quiz score. The study created an assessment rubric for student worksheets and quiz questions along with their assessment rubrics. In addition to designing the "HAK & NITNA" learning media, student worksheets, quiz questions, the researcher also designed interview guidelines, lesson plans, interview guideline validation sheets, "HAK & NITNA" learning media validation sheets, student worksheets validation sheets, lesson plan validation sheets, quiz question validation sheets, student response questionnaire validation sheets, student activity observation sheet validation sheets, and teacher activity observation sheet validation sheets.

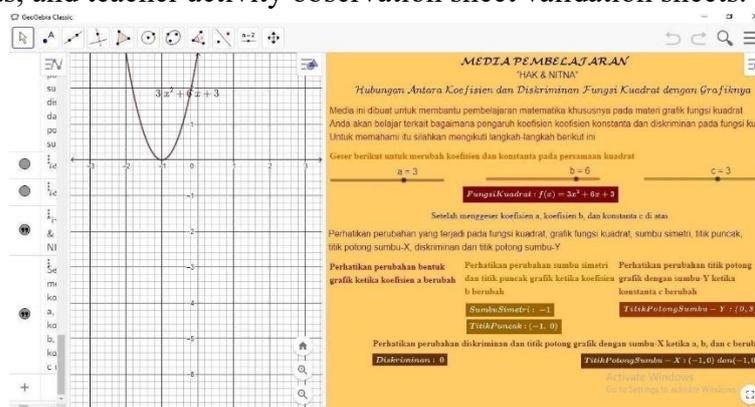


Figure 1. Display of Learning Media "HAK and NITA"

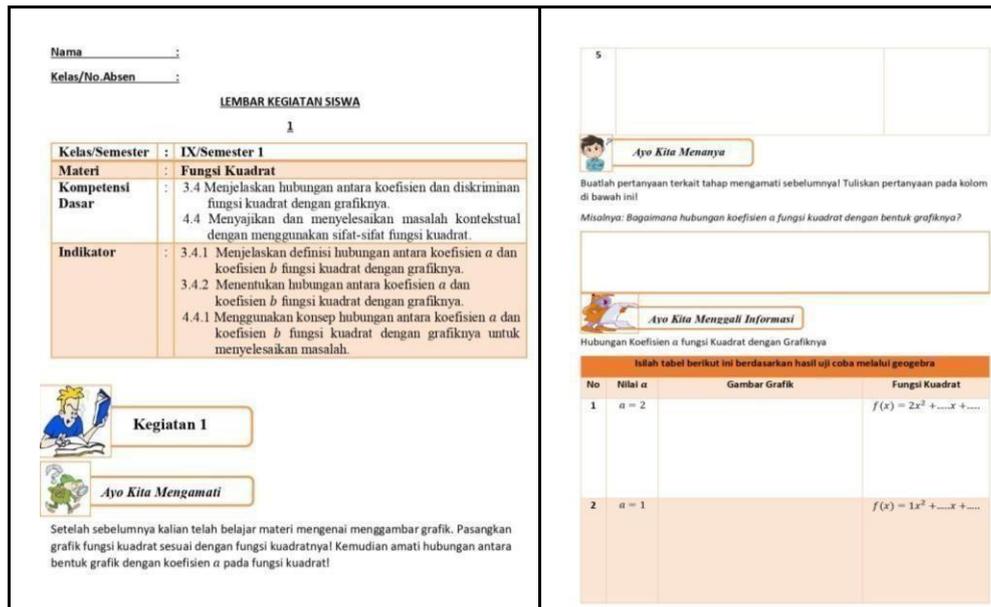


Figure 2. Student Worksheet Display

Development Stage

At this development stage, the “HAK & NITNA” learning media, student worksheets, quiz questions, interview guidelines, lesson implementation plans, interview guideline validation sheets, “HAK & NITNA” learning media validation sheets, student worksheets validation sheets, lesson implementation plans validation sheets, quiz question validation sheets, student response questionnaire validation sheets, teacher activity observation sheet validation sheets, and student activity observation sheet validation sheets from beginning to end were created, followed by validation by experts. The experts who validated in this study were mathematics lecturers at Malang State University and mathematics teachers at Shalahuddin Middle School, Malang. In the limited trial, several inputs were obtained from the validator for the improvement of open materials. Among them, the use of the word "coefficient" should be written only once to be more efficient, and instructions such as "swipe the following to change the coefficients and constants of the quadratic equation" need to be added so that students better understand how to interact with the media. In addition, the validator suggested that the selection of content colors have sufficient contrast with the background, and the importance of including instructions for use on student worksheets so that their use is more focused. The results of filling out the validation sheets will produce quantitative data in the form of validator assessment scores and qualitative data in the form of improvement notes, comments, or suggestions.

- The results of the interview guideline validity test analysis obtained a validity of 97%. This means that the interview guideline is included in the very valid requirements.
- The results of the “hak & nitna” learning media validity test analysis obtained a validity of 92%. This means that the “HAK & NITNA” learning media is included in the very valid requirements.
- The results of the validity test analysis of the worksheet obtained a validity of 94%. This means that the worksheet is included in the very valid requirements.
- The results of the validity test analysis of the lesson implementation plans obtained a validity of 94%. This means that the lesson implementation plans is included in the very valid requirements.
- The results of the validity test analysis of the quiz questions obtained a validity of 91%. This means that the quiz questions are included in the very valid requirements.

- f. The results of the validity test analysis of the student response questionnaire obtained a validity of 95%. This means that the student response questionnaire is included in the very valid requirements.
- g. The results of the validity test analysis of the student activity observation sheet obtained a validity of 93%. This means that the student activity observation sheet is included in the very valid requirements.
- h. The results of the validity test analysis of the teacher activity observation sheet obtained a validity of 92%. This means that the teacher activity observation sheet is included in the very valid requirements.

In this validation process, the researcher also received several notes for improvement, comments, or suggestions about the content of the research instrument.

4. Implementation Stage

After obtaining the validation results, the researcher conducted a field test. Field testing was conducted on 32 students of SMP Shalahuddin Malang class IX D, but because 2 people were absent due to illness and 1 person was absent due to no explanation. So, the study was conducted on 29 students of SMP Shalahuddin Malang class IX D. This study was conducted face-to-face with a limited time of 7×40 minutes which was divided into 3 meetings with a division of 2×40 minutes for the first meeting, 3×40 minutes for the second meeting, and 2×40 minutes for the third meeting. This field test was conducted by the researcher to determine the practicality and effectiveness of the product. The level of practicality of the product was determined based on the results of the student response questionnaire, student activity observation sheets, and teacher activity observation sheets. The level of product effectiveness was determined based on the results of the student quiz questions. The practicality test was obtained from the learning media "HAK & NITNA" and student worksheets that had previously been developed and tested on students. After using the "HAK & NITNA" learning media and student worksheets in the learning process, students will fill out the student response questionnaire sheet to determine the level of practicality of the "HAK & NITNA" learning media and student worksheets. In addition, teachers will also fill out the student activity observation sheet and the teacher activity observation sheet to determine the level of practicality of the "HAK & NITNA" learning media and student worksheets.

- a. The results of the practicality test analysis of the student response questionnaire obtained a practicality of 88%. This means that the "HAK & NITNA" learning media and student worksheets are included in the very practical requirements.
- b. The results of the practicality test analysis of the student activity observation sheet obtained a practicality of 96%. This means that the "HAK & NITNA" learning media and student worksheets are included in the very practical requirements.
- c. The results of the practicality test analysis of the teacher activity observation sheet obtained a practicality of 96%. This means that the "HAK & NITNA" learning media and student worksheets are included in the very practical requirements.
- d. The results of the practicality test analysis of the teacher activity observation sheet obtained a practicality of 96%. This means that the "HAK & NITNA" learning media and student worksheets are included in the very practical requirements.
- e. Results of the Analysis of the Effectiveness Test of Quiz Questions

The effectiveness test was obtained from the quiz questions that had previously been developed and tested on students. The quiz questions that had been developed contained

questions about the material on the relationship between the coefficient and discriminant of the quadratic function with its graph. The Effectiveness Test was obtained from the total average of students who obtained a minimum average score of KKM from the total students who were the subjects of the study. The score that meets the minimum school completion requirements (KKM) in mathematics is 80. Based on the data from the results of the effectiveness test of the quiz questions above. From a total of 29 students who were the subjects of the study and 27 students who obtained a minimum average score of KKM.

The results of the study indicate that the “HAK & NITNA” learning media and student worksheets developed have met the criteria of valid, practical, and effective. The validity of the media is reflected in the high percentage of validity in various instruments, such as interview guidelines (97%), learning media (92%), student worksheets (94%), lesson implementation plans (94%), quiz questions (91%), student response questionnaires (95%), and observation sheets for student activities (93%) and teachers (92%). This high level of validity is in line with the findings of Laylani Harahap and Yahfizham (2024), which state that the use of GeoGebra in mathematics learning can significantly improve students' understanding of concepts. The practicality of the media is also evident from the results of the student response questionnaire (88%) and observations of student and teacher activities (96% each). This shows that the media is easy to use and well received by users. These findings are supported by research by Nurrohman et al. (2024), who found that the use of GeoGebra in mathematics learning increases students' interest and motivation, and makes it easier to understand abstract concepts.

The effectiveness of the media can be seen from the quiz results which show an effectiveness percentage of 93%. This shows that the media is able to improve student learning outcomes. Research by Usman et al. (2023) also shows that the use of GeoGebra in mathematics learning, especially in the material on quadratic function graphs, is effective in improving student understanding. Overall, the development of the “HAK & NITNA” learning media and student worksheets with the ADDIE model—starting from needs analysis, design, development, implementation, to evaluation—has succeeded in creating valid, practical, and effective media. This process supports the integration of technology in mathematics learning, which is in line with efforts to improve the quality of education in the digital era.

CONCLUSION

This study has created a computer-assisted learning media product called "HAK & NITNA" and student worksheets with the ADDIE model. The first stage is the analysis stage. The results at this stage are information that students still experience obstacles when studying the material of quadratic function graphs. The effectiveness of the media used is quite large because if only lectures or blackboards are used, students do not grasp the material being taught. The majority of students' learning styles are visual (given pictures) or move directly. The second stage is the design stage. The results at this stage are the design of the "HAK & NITNA" learning media, student worksheets, student worksheets assessment rubric, quiz questions, and quiz question assessment rubric. In addition, the design of interview guidelines, lesson implementation plans, interview guideline validation sheets,

"HAK & NITNA" learning media validation sheets, student worksheets validation sheets, lesson implementation plans validation sheets, quiz question validation sheets, student response questionnaire validation sheets, student activity observation sheet validation sheets, and teacher activity observation sheet validation sheets. The third stage is the development stage. The results at this stage are the development of research instruments. The development of research instruments was developed based on the results of the previous design. The research instruments that have been developed will be validated by experts in this case, mathematics lecturers at Malang State University and mathematics teachers at Shalahuddin Middle School Malang. The results of the assessment of the interview guideline validation sheet, "HAK & NITNA" learning media, student worksheets, lesson implementation plans, quiz questions, student response questionnaires, student activity observation sheets, teacher activity observation sheets, obtained a percentage of validity respectively of 97%, 92%, 94%, 94%, 91%, 95%, 93%, 92%. The fourth stage is the implementation stage. The results at this stage are the level of practicality and effectiveness of the product. The level of practicality of the product based on the results of the student response questionnaire, student activity observation sheets, teacher activity observation sheets obtained a percentage of practicality respectively of 88%, 96%, and 96%. The level of product effectiveness based on the results of student quiz questions and obtained a percentage of effectiveness of 93%. One of the obstacles faced by students is applying the concept, namely students are not yet skilled in applying the principle of the axis of symmetry and drawing quadratic function graphs on Cartesian diagrams. Overall, computer-assisted learning media with the name "HAK & NITNA" and student worksheets are media that meet the requirements of being valid, practical, and effective to facilitate students in understanding the concept of the relationship between the coefficient and discriminant of a quadratic function with its graph. The results of this study indicate that the development of interactive learning media based on GeoGebra can be a solution to help students understand abstract concepts in quadratic functions visually and dynamically. Therefore, mathematics teachers can consider using similar media to increase student engagement in learning. In addition, these results reinforce the importance of technology integration in discovery-based learning approaches.

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