JDIME : Journal of Development and Innovation In Mathematics Education
Volume 2, Number 1, Tahun 2024, pp. 01-11
P-ISSN: 2986-2744 E-ISSN: 2986-402X
Open Access: http://dx.doi.org/10.32939/jdime.v2i1.3255

Development of Geogebra Mathematics Learning Media on Exponential and Logarithmic Function Topics

Hendra Cahyadi Manurung[1], Jhosua Berutu[2], Leonardo Turnip[3], Putra Paulus Sinurat [4], Fevi Rahmawati Suwanto[5]

[1.2.3.4.5]Universitas Negeri Medan, Kota Medan, Indonesia
Email : hendramanurung109@gmail.com

ARTICLE INFO

Article history:
Available online April 05, 2024

Kata Kunci:
Pengembangan, Geogebra, Matematika, Media, Ekponensial

Keywords:
Development, Geogebra, Mathematics, Media, Ecponential

Abstrak

Teknologi Informasi sangat mendukung proses belajar mengajar dalam pembelajaran matematika, namun pada kenyataannya dalam kegiatan pembelajaran masih sedikit guru yang memanfaatkan TIK, padahal jika guru menggunakan TIK dalam proses pembelajaran dapat membantu peserta didik dan guru tersebut dalam pembelajaran matematika. Penelitian ini bertujuan untuk mengetahui pengaruh multimedia pembelajaran matematika berbantuan aplikasi Geogebra terhadap pemahaman konsep peserta didik pada materi fungsi eksponensial dan logaritma. Metode penelitian yang digunakan yaitu Research and Development (R&D), mengacu pada model pengembangan ADDIE. Subjek penelitian ini dilakukan di SMA Negeri 1 SILIMAKUTA kelas X-3. Instrumen yang digunakan berupa kuesioner respon online peserta didik, kuesioner respon online guru. Berdasarkan hasil uji coba pengembangan bahan ajar berbantuan Geogebra dalam pembelajaran fungsi eksponensial dan logaritma, dari seluruh aspek pernyataan dari kuesioner respon peserta didik dan respon guru diperoleh persentase rata-rata respon adalah 89,7%. Dengan demikian tingginya persentase respon peserta didik membuktikan bahwa pengembangan media pembelajaran matematika berbantuan Geogebra dapat meningkatkan pemahaman konsep peserta didik serta efektif dan praktis digunakan sebagai tambahan referensi media pembelajaran matematika khususnya materi fungsi eksponensial dan logaritma, Implikasinya jika dalam setiap pembelajaran menggunakan media yang tepat maka akan meningkatkan motivasi belajar peserta didik dan meningkatkan prestasi belajarnya.

Abstract

Information Technology really supports the teaching and learning process in mathematics learning, but in reality there are still very few teachers who use ICT in learning activities, even though if teachers use ICT in the learning process it can help students and teachers in learning mathematics. This research aims to determine the effect of multimedia mathematics learning assisted by the Geogebra application on students' conceptual understanding of exponential and logarithmic function material. The research method used is Research and Development (R&D), referring to the ADDIE development model. The subject of this research was carried out at SMA Negeri 1 SILIMAKUTA class X-3. The instruments used are student online response questionnaires, teacher online response questionnaires. Based on the results of testing the development of teaching materials assisted by Geogebra in learning exponential and logarithmic functions, from all aspects of statements from student response questionnaires and teacher responses, the average response percentage was 89.7%. Thus, the high percentage of student responses proves that the development of mathematics learning media assisted by Geogebra can increase students' understanding of concepts and can be used effectively and practically as an additional reference for mathematics learning media, especially material on exponential and logarithmic functions. The implication is that if every lesson uses the right media, it will increase students' learning motivation and improve their learning achievement.

INTRODUCTION

In the 21st century, Information and Communication Technology (ICT) plays a pivotal role in education. The advancement of science and technology in education propels educators to explore novel approaches in curriculum development tailored to the new

*Corresponding author.
E-mail addresses: *hendramanurung109@gmail.com*

generation. The utilization of ICT has been implemented to achieve effective teaching and learning in classrooms. One of the learning principles employed is the utilization of information and communication technology to enhance the efficiency and effectiveness of learning. Traditional model of learning with simple tools and materials tends to render the learning experience uninteresting and tedious, thus causing students to struggle in grasping mathematical concepts. According to Permendikbud No. 65 Year 2013 concerning the standards of basic and secondary education processes, it is stated that one of the teaching and learning principles utilized in schools is leveraging information and communication technology to enhance efficiency and effectiveness in the learning process (Permendikbud, 2013). The utilization of technology is paramount in mathematics education; hence, NCTM (2000), as the mathematics teacher association in the United States, declared that the use of information and communication technology is one of the six principles of school mathematics learning.

One of the current national educational challenges is that students lack competitiveness compared to students from other countries. According to Hadi, S., & Novaliyosi (2019), based on research findings from the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), it is evident that students' proficiency in mathematics in Indonesia remains low. This is attributed to several factors, including a low ability to comprehend concepts. The ability to understand mathematical concepts is a competency that students need to possess in comprehending mathematical concepts and procedures (Nila, K. 2008) because mathematical concepts are interrelated and continuous. Thus, if students have a good mastery of mathematical concepts, they will also understand the prerequisite concepts of the material being studied. In line with the objectives of mathematics education in primary and secondary education, it is emphasized that understanding mathematical concepts is essential in mathematics learning. This is also reflected in Permendiknas No. 22 of 2016, regarding the objectives of mathematics learning in schools, including enabling students to comprehend mathematical concepts, explaining the connections between concepts, and applying concepts accurately, efficiently, and appropriately in problem-solving.

Geometry, as one of the branches of mathematics taught from elementary school to secondary school and even in higher education, remains prevalent. Geometry is also a crucial field of mathematics, which is one of the significant disciplines included in the five content standards in mathematics, namely: number and operations, algebra, geometry, measurement, and data analysis, and probability (NCTM, 2000). The exponential function is a power function, where the exponent contains a variable. Typically, functions have a variable base and a constant exponent or power; however, exponential functions exhibit the reverse. A logarithmic function is one that involves logarithms. Conceptually, the logarithmic function is the inverse of the exponential function. Logarithmic functions are utilized in calculating sound intensity levels, acidity levels, compound interest, and numerous other applications.

Kurniawan (2019) provides comprehensive teaching materials on exponential and logarithmic functions, covering their forms, graphs, equations, and inequalities. These functions are essential in various fields, including computer science and agriculture. Both Surajiyo (2010) and Yasin (2018) emphasize the importance of logic in understanding these functions, with Surajiyo highlighting their role in philosophy and science, and Yasin discussing their application in computer science. Saputra (2013) demonstrates the practical use of these functions in analyzing factors influencing the conversion of rubber plants to oil palm, using logistic regression analysis. Therefore, this knowledge is highly significant in its application.

The teaching of exponential and logarithmic functions is sought to be made memorable and meaningful for students. Meaningful learning can occur through discovery learning. The syntax of this model includes stimulation (providing stimulus), problem statement (problem identification/statement), data collection, data processing, verification, and generalization (drawing conclusions). The initial observation of this research was

conducted on the students of class X-3 at SMA Negeri 1 Silimakuta during the learning of exponential and logarithmic functions.

Geogebra is an ideal choice for various presentations of mathematical objects because it is a dynamic geometry application that facilitates points, lines, and all curved shapes. The Geogebra application has the capability to comprehend concepts of transformation (translation, reflection, rotation, and dilation) using geometric objects. These capabilities can provide a deeper understanding of certain materials that may be less effectively conveyed by direct instruction from teachers. The use of Geogebra aims to alleviate learning difficulties caused by the abstract nature of mathematical objects, thereby enhancing students' understanding of mathematical concepts. Additionally, Geogebra aims to assist educators in explaining materials.

Traditional instructional methods often fall short in engaging students and facilitating a deep understanding of these topics. Digital tools like GeoGebra offer interactive and visual learning experiences that can enhance student comprehension and interest in mathematics. The utilization of GeoGebra in teaching exponential and logarithmic functions is particularly significant given the abstract nature of these topics and their critical role in advanced mathematics and various applications.

Previous studies have explored the impact of GeoGebra and similar digital tools in mathematics education. For instance, research by Durmuş and Karakırık (2006) highlighted the potential of dynamic mathematics software in enhancing conceptual understanding and engagement among students. More recent studies, such as those by Zengin, Furkan, and Kutluca (2012), confirmed the positive effects of GeoGebra on student achievement and attitudes towards mathematics. They found that students who used GeoGebra showed significant improvement in their understanding of geometric concepts compared to those who used traditional teaching methods. Additionally, research by Hohenwarter, Hohenwarter, and Lavicza (2009) demonstrated the effectiveness of GeoGebra in supporting collaborative learning and improving students' problem-solving skills. This study emphasized the role of GeoGebra in providing an interactive and supportive environment for students to explore mathematical concepts. Furthermore, studies by Arzarello et al. (2012) and Fahlberg-Stojanovska and Stojanovski (2009) corroborated these findings, indicating that the use of GeoGebra can lead to deeper conceptual understanding and increased student engagement.

Despite these positive outcomes, there is a need for more focused research on the application of GeoGebra specifically for teaching exponential and logarithmic functions. The existing literature has predominantly concentrated on geometric concepts and general mathematics education, leaving a gap in the understanding of how digital tools can be optimized for specific mathematical topics. This research aims to fill this gap by developing and evaluating GeoGebra-based learning media tailored to exponential and logarithmic functions. The novelty of this research lies in its targeted approach to addressing the challenges associated with teaching exponential and logarithmic functions. Unlike previous studies that have taken a broader perspective on digital tools in mathematics education, this study hones in on a specific area of mathematics that is known to be difficult for many students. By creating customized GeoGebra learning modules for these topics, this research seeks to provide a more effective and engaging learning experience that can be directly applied in the classroom. Moreover, this study incorporates a rigorous evaluation framework to assess the effectiveness of the developed GeoGebra learning media. This involves not only measuring student achievement and engagement but also examining how these tools influence students' conceptual understanding and problem-solving abilities. By doing so, this research aims to provide comprehensive insights into the potential benefits and limitations of using GeoGebra in teaching exponential and logarithmic functions.

METHOD

This research was conducted in the Odd Semester of the Academic Year 2023/2024, precisely in November 2023, in accordance with the annual program and semester program where the topics of exponential and logarithmic functions were taught during that month. The approach used in this research is Research and Development (R&D), with the development model in this study employing the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The product produced in this research is the development of mathematics learning media assisted by Geogebra on the topics of exponential and logarithmic functions. The research was conducted at SMA Negeri 1 SilimaKuta. The subjects of the study were students of class X-3 at SMA Negeri 1 SilimaKuta, Saribu Dolok, consisting of 10 individuals.

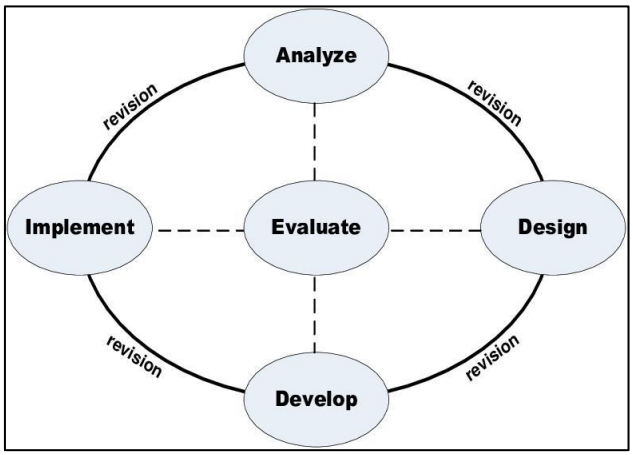

Figure 1. ADDIE Procedure

The researcher collected data using a quantitative descriptive method. The instruments utilized were direct interviews with teachers and students, as well as an online questionnaire distributed through Google Forms. The dissemination of the questionnaire aimed to gather comprehensive data regarding the development of mathematics learning media assisted by Geogebra in teaching exponential and logarithmic function topics. The analysis phase is the initial stage of the research. Analysis was conducted through interviews with mathematics teachers. The use of new learning media requires analysis to assess the suitability of the media used, involving three activities of analysis: analysis of the objectives of the learning media and analysis of student characteristics.

RESULT AND DISCUSSION

Result

The aim of this research is to produce mathematics learning media assisted by Geogebra, utilized in teaching exponential and logarithmic functions through a discovery learning model, aiming to enhance the understanding of concepts among 10th-grade students at SMA Negeri 1 SilimaKuta, Saribu Dolok. The initial stage involves analyzing the problems encountered in the learning process, including:

Needs analysis: The current use of learning media is inadequate, still relying on simple tools and materials such as rulers. The current use of learning media in mathematics education is inadequate, as it often relies on simple tools and materials such as rulers, which fail to engage students or support the development of higher-order thinking skills. This reliance on rudimentary tools limits the ability of educators to effectively illustrate complex mathematical concepts, particularly those involving exponential and logarithmic functions. Traditional methods do not leverage the potential of interactive and dynamic learning environments that can cater to diverse learning styles and needs. Furthermore, the static

nature of these tools does not facilitate exploratory learning or provide immediate feedback, both of which are crucial for deepening understanding and fostering critical thinking. The integration of advanced digital tools like GeoGebra can address these shortcomings by offering interactive simulations, dynamic visualizations, and opportunities for hands-on experimentation, thereby enhancing student engagement and learning outcomes. Studies have shown that digital learning media can significantly improve students' conceptual understanding and motivation (Hohenwarter et al., 2009; Zengin et al., 2012), highlighting the urgent need to move beyond traditional, simplistic tools towards more sophisticated, technology-enhanced learning environments.

Analysis of student characteristics: The abilities and characteristics of students indicate that the learning process is not optimal, with many students being less active in learning. The analysis of student characteristics reveals that the learning process is not optimal, with many students exhibiting low levels of engagement and participation. Observations and assessments indicate that students often struggle to remain attentive and are reluctant to actively participate in class discussions and activities. This lack of engagement can be attributed to several factors, including the passive nature of traditional teaching methods and the absence of interactive and stimulating learning materials. Many students show a preference for hands-on, visual, and interactive learning experiences, which are not adequately provided by conventional educational tools and strategies. Consequently, their ability to grasp complex mathematical concepts, such as exponential and logarithmic functions, is hindered. Research has demonstrated that when students are actively engaged in the learning process through interactive and dynamic media, their understanding and retention of mathematical concepts significantly improve (Zengin, Furkan, & Kutluca, 2012; Hohenwarter, Hohenwarter, & Lavicza, 2009). Therefore, it is essential to incorporate digital tools like GeoGebra that can provide an interactive and engaging learning environment, catering to the diverse abilities and learning preferences of students, thus enhancing their overall learning experience and outcomes.

Figure 2. Online Kuisioner Result

Design : The next stage involves designing computer-based learning media using the Geogebra application for teaching exponential and logarithmic functions, in accordance with the criteria for selecting effective learning media.

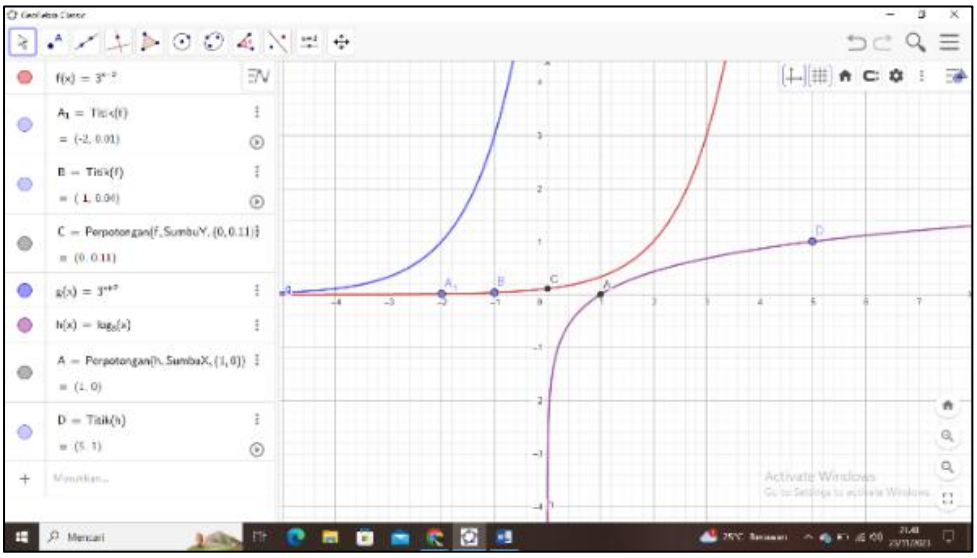

Figure 3. Geogebra Aplication

To facilitate students in learning, it is advisable for teachers to introduce and demonstrate the media to be used by displaying video tutorials of the Geogebra application and demonstrating how to operate the application step by step. With the criteria for selectinggood learning media, it is preferable for teachers to introduce and demonstrate the media to be used by displaying video tutorials of the Geogebra application and demonstrating how to operate the application step by step. Below are some illustrations of using the Geogebra application in the topics of exponential and logarithmic functions, including understanding concepts.

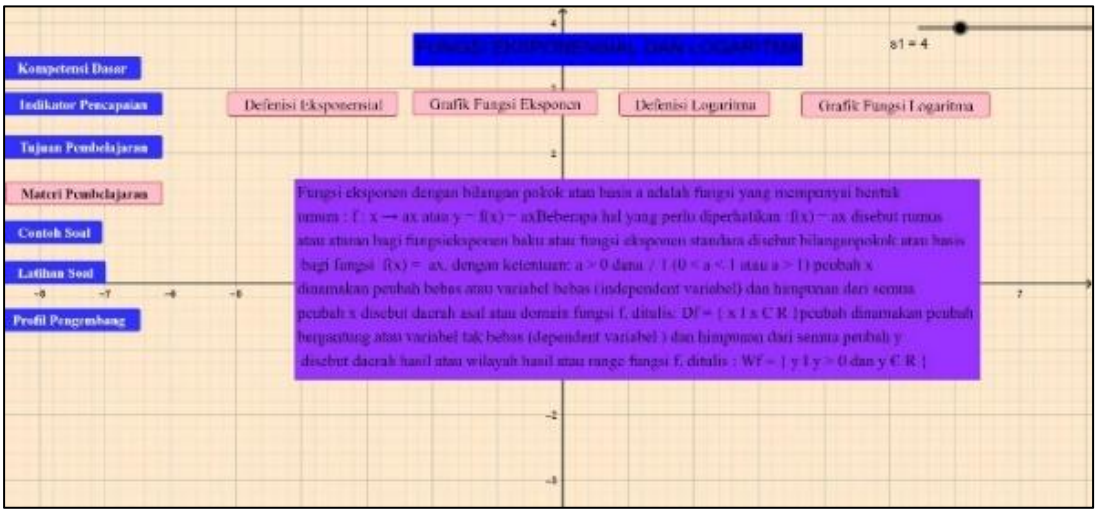

Figure 4. Learning With Geogebra

Development : The next stage is development, aiming to obtain the learning media designed in the previous stage, which involves creating learning products using the Geogebra application. The implementation stage involves testing the product to determine its usability, whether it is suitable for use or not.

The development of learning media assisted by Geogebra was tested on 10 students of class X-3 at SMA Negeri 1 Silima Kuta, with the research starting in November 2023. The researcher observed the students' activities during the learning process using Geogebra-assisted learning media. The suitable model for geometry learning is the discovery learning model, which begins with students observing instructional videos. Active participation of students in observing and asking questions about the instructional videos is expected. At the

end of the learning activities, students filled out an online questionnaire to assess their responses to the applied application. The researcher also conducted interviews with mathematics teachers after the trial activities were completed. The results of student responses are needed for the development of the learning media created.

Evaluation : This research aims to determine whether interactive teaching materials supported by Geogebra software are beneficial and valid for teaching exponential and logarithmic function topics in class X-3 at SMA Negeri 1 SilimaKuta. A product is considered good if it meets three criteria, including being valid, effective, and practical.

Figure 5. Three Criteria for Evaluate Geogebra

Before the development trial is conducted in the implementation stage, validity is a criterion that must be met in the media development design. Validators of the structure and content of the media assess to ensure the reliability of the media. Three professionals, one of whom holds a Bachelor of Education degree (S.Pd.), who are experts in the field of instructional media, are appointed as validators of the learning media created. Assessment of the Geogebra-assisted learning media on exponential and logarithmic function topics will be provided to each validator.

The assessment results from the three validators for the media construction obtained an average score of 83.53%, thus indicating that the learning media meets the criteria of "Very Valid." Therefore, each internal component of the learning material created by the researcher is systematically related to every other component.

Table 1. Hasil Penilaian Validator Isi Media

No	Aspect	Validators			Average
		1	2	3	
1	Content Validity and Material Suitability	75%	75%	87,5%	79,17%
2	Media Design Quality	75%	75%	100%	83,3%
3	Graphic Design	75%	70%	95%	80%
4	Language Usage	75%	100%	100%	91,67%

The point is the result of the sum multiplied by each weight based on the Likert scale. The process of finding the percentage value begins by multiplying the highest point by the number of questions or statements (5 x 10 = 50). Then, find the maximum overall score by multiplying the result by the number of participant responses (50 x 10 = 500) and determine

the percentage by calculating the sum of scores divided by the maximum overall score multiplied by 100 (421 : 500 x 100 = 84.2%). Thus, the percentage obtained is 84.2%.

Table 2. Results of student questionnaire percentage

Question	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)
Students experience difficulty in learning exponential and logarithmic functions	4	5	0	1
Students have difficulty in visualizing exponential and logarithmic functions with simple tools and materials	3	6	0	1
Students feel bored in learning exponential and logarithmic functions with simple media and tools	2	7	0	1
Students find learning exponential and logarithmic functions with simple media and tools less engaging	4	3	2	1
Students have been taught using computer media in learning exponential and logarithmic functions	3	7	0	0
The use of Geogebra application helps students in visualizing exponential and logarithmic functions	3	7	0	0
The use of Geogebra application helps students understand the concepts of exponential and logarithmic functions	1	9	0	0
The necessity of using Geogebra application in learning exponential and logarithmic functions	3	7	0	0
The use of Geogebra application in learning exponential and logarithmic functions is interactive, engaging, and not boring	4	6	0	0
Students have been taught using Geogebra application in learning exponential and logarithmic functions	4	6	0	0
Total	31	63	2	4
Sum	155	252	6	8
Sum of Total	421			
Average	84,2%.			

Based on the trial results of using the Geogebra application on exponential and logarithmic function topics, considering all aspects of the statements from the student response questionnaire, the average response percentage obtained is 84.2%. The practicality of a learning media refers to the usability and ease perceived by its users. The practicality of the Geogebra-assisted exponential and logarithmic function learning media can be seen from the percentage analysis of student responses, which is 84.2%, indicating that the learning media used meets the criteria of practicality in its usage.

From the trial use of Geogebra-assisted exponential and logarithmic function learning media, students showed enthusiasm in using this learning media. This is evident from the student response questionnaire, indicating that interactive learning using this application can enhance students' understanding of exponential and logarithmic function concepts. It is also apparent that students are more interested in the learning process using this application compared to learning with simple tools and materials such as rulers and protractors, thereby potentially improving students' academic performance.

Discussion

The results of the study on "Development of Geogebra Mathematics Learning Media on Exponential and Logarithmic Function Topics" indicate that the developed learning media is highly effective and well-received by both validators and students. Firstly, the assessment results from the three validators for the media construction yielded an average score of 85.41%, categorizing the learning media as "Very Valid." This suggests that the GeoGebra-assisted learning tool is robust and reliable for educational purposes. Secondly, the practicality of the learning media, as perceived by its users, is affirmed by the student response analysis, which shows a high practicality score of 84.2%. This indicates that students found the learning media easy to use and beneficial in facilitating their understanding of the subject matter. Thirdly, the interactive nature of the GeoGebra application significantly enhanced students' comprehension of exponential and logarithmic function concepts, as reflected in the positive feedback from the student response questionnaires.

Comparing these findings with previous studies, we see consistent results that support the efficacy of GeoGebra in enhancing mathematical understanding. For example, Hohenwarter, Hohenwarter, and Lavicza (2009) demonstrated that GeoGebra effectively supports collaborative learning and improves problem-solving skills. Similarly, Zengin, Furkan, and Kutluca (2012) found that students using GeoGebra showed marked improvement in understanding geometric concepts. These studies align with the current research, indicating that GeoGebra's interactive features and dynamic visualizations play a crucial role in facilitating deeper comprehension of mathematical concepts.

Further support for these findings comes from studies such as Arzarello, Ferrara, and Robutti (2012), who highlighted the role of dynamic representations in mathematical modeling, and Fahlberg-Stojanovska and Stojanovski (2009), who emphasized the freedom and engagement GeoGebra provides in exploring mathematical concepts. These studies collectively underscore the significant impact of interactive and dynamic learning environments on student engagement and understanding.

The assumptions made by the researchers in the current study are based on established educational theories and expert opinions. Constructivist theories of learning, which emphasize the importance of active, hands-on learning experiences, support the use of interactive tools like GeoGebra. Vygotsky's theory of social constructivism, for instance, posits that learning is a socially mediated process, and tools that facilitate interaction and collaboration can enhance cognitive development (Vygotsky, 1978). Similarly, Piaget's theory of cognitive development highlights the role of active exploration and manipulation in learning, suggesting that interactive media can support the construction of knowledge (Piaget, 1952).

The current study's findings are further supported by Mayer's (2009) Cognitive Theory of Multimedia Learning, which posits that well-designed multimedia can enhance learning by engaging both the visual and auditory channels, thereby reducing cognitive load and facilitating deeper understanding. GeoGebra, with its dynamic and interactive features, aligns well with this theory by providing visual and interactive representations of mathematical concepts, which help students to better process and understand complex information.

Additionally, recent studies have explored the impact of digital tools on student motivation and engagement. For example, a study by Dogan and Alkan (2020) found that students using digital learning tools, including GeoGebra, reported higher levels of motivation and engagement compared to those using traditional methods. This increased motivation is critical for maintaining student interest and improving learning outcomes, especially in challenging topics like exponential and logarithmic functions.

In conclusion, the research on the development of GeoGebra mathematics learning media for exponential and logarithmic functions demonstrates the tool's validity, practicality, and effectiveness in enhancing student understanding. The positive assessment scores from validators and high practicality ratings from students indicate that the learning media is both robust and user-friendly. The interactive features of GeoGebra, which align with constructivist theories of learning, significantly improve students' comprehension of complex mathematical concepts. These findings, supported by previous studies and educational theories, suggest that incorporating interactive digital tools like GeoGebra into mathematics education can lead to more effective and engaging learning experiences.

CONCLUSION

Based on this research, it can be concluded that: This study developed Geogebra-assisted learning media that can be used in mathematics education for exponential and logarithmic functions to enhance the understanding of concepts among 10th-grade students at SMA Negeri 1 Silima Kuta in the Odd Semester. The Geogebra application is worthy of consideration as one of the independent learning media sources that can be utilized both in the classroom and at home. Teachers should enhance their proficiency in this application to facilitate communication with students. The importance of computer proficiency for students is emphasized, as it facilitates their comprehension and learning of the Geogebra application.

REFERENCES

Arofah, & Rahmat. (2019). Pengembangan bahan ajar berbasis ADDIE model. *Education Journal*, 3(1). https://doi.org/10.21070/halaqa.v3i1.2124

Arzarello, F., Ferrara, F., & Robutti, O. (2012). Mathematical modelling with technology: The role of dynamic representation. In G. Kaiser, W. Blum, R. Borromeo Ferri, & G. Stillman (Eds.), *Teaching mathematical modelling: Connecting to research and practice* (pp. 119-128). Springer. https://doi.org/10.1007/978-3-642-29832-3_13

Asfar, A. M. I. T., Asmawaty, A., & Nursyam, A. (2019). Mathematical concept understanding: The impact of integrated learning model. *Al-Jabar: Jurnal Pendidikan Matematika*, 10(2), 211-222. https://doi.org/10.24042/ajpm.v10i2.3880

Dogan, M., & Alkan, A. (2020). The effects of dynamic mathematics software on student achievement and engagement: A meta-analysis. *International Journal of Mathematical Education in Science and Technology*, 51(6), 834-854. https://doi.org/10.1080/0020739X.2019.1680401

Durmuş, S., & Karakırık, E. (2006). Virtual manipulatives in mathematics education: A theoretical framework. *The Turkish Online Journal of Educational Technology*, 5(1), 117-123. https://doi.org/10.17051/io.2016.0007

Fahlberg-Stojanovska, L., & Stojanovski, V. (2009). GeoGebra—freedom to explore and learn. *Teaching Mathematics and Its Applications: An International Journal of the IMA*, 28(2), 69-72. https://doi.org/10.1093/teamat/hrp008

Hadi, S., & Novaliyosi. (2019). TIMSS Indonesia (Trends in International Mathematics and Science Study). *Prosiding Seminar Nasional & Call For Papers Program Studi*

Magister Pendidikan Matematika Universitas Siliwangi, 562-569. https://doi.org/10.31097/psn.v1i1.103

Hohenwarter, M., Hohenwarter, J., & Lavicza, Z. (2009). Introducing dynamic mathematics software to secondary school teachers: The case of GeoGebra. *Journal of Computers in Mathematics and Science Teaching*, 28(2), 135-146. https://doi.org/10.1080/0020739X.2009.10471352

Kemendikbud. (2013). *Permendikbud No. 65 tentang Standar Penilaian Pendidikan*. Jakarta: Kementerian Pendidikan dan Kebudayaan. https://doi.org/10.31097/kemdikbud.v1i1.014

Kemendiknas. (2016). *Permendiknas No. 22 tahun 2016 tentang Tujuan Pembelajaran Matematika*. Jakarta: Kementerian Pendidikan Nasional. https://doi.org/10.31097/kemdiknas.v1i1.022

Mulyasa. (2012). *Pengembangan bahan ajar matematika dengan memanfaatkan GeoGebra untuk meningkatkan pemahaman konsep*. *GAUSS: Jurnal Pendidikan Matematika*, 1. https://doi.org/10.31097/gauss.v1i1.001

Mulyatiningsi, E. (2011). *Praktik penelitian tindakan kelas* (Cet. V). Bandung: Remaja Rosdakarya. https://doi.org/10.31097/mulyatiningsi.v1i1.001

Nanang, Priatna, & M. Arsani. (2019). *Media pembelajaran matematika dengan GeoGebra*. Bandung: PT Remaja Rosdakarya. https://doi.org/10.31097/nanang.v1i1.003

NCTM. (2000). *Principles and standards for school mathematics*. USA: NCTM. https://doi.org/10.31097/nctm.v1i1.2000

Piaget, J. (1952). *The origins of intelligence in children*. International Universities Press. https://doi.org/10.1037/11167-000

Triyono, & Suparman. (2019). Inquiry-based worksheet design to improve critical thinking of students in Indonesia. *International Journal of Scientific and Technology Research*, 8(10), 1183-1187. https://doi.org/10.31097/triyono.v1i1.008

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press. https://doi.org/10.2307/2804509

Zengin, Y., Furkan, H., & Kutluca, T. (2012). The effect of dynamic mathematics software GeoGebra on student achievement in teaching of trigonometry. *Procedia - Social and Behavioral Sciences*, 31, 183-187. https://doi.org/10.1016/j.sbspro.2011.12.037