**International Journal on Emerging Mathematics Education (IJEME)**
Vol. 6, No. 2, September 2022, pp. 149-158
P-ISSN: 2549-4996, E-ISSN: 2548-5806, DOI: http://dx.doi.org/10.12928/ijeme.v6i2.22444

# Development of GeoGebra-Assisted Digital Learning Media for Geometry Transformation Materials based on Van Hiele's Theory

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**Abstract**

This research aims to develop valid, practical, and effective digital learning media. This development research method is Research and Development (R&D) with the ADDIE development model. The development of this digital learning media produces products in the form of android applications (apk) and websites that can be used via mobile phones or computers. The research process begins by analyzing the problems that exist in the learning process in schools. Then proceed with determining and preparing the design of the learning media. The collected materials were then developed into learning media with the help of GeoGebra, Ispring, Android Studio, and Notepad++. Then validation was carried out by media experts, material experts, learning experts, and practitioners and field trials were given to high school students in class XI. In the preparation of this learning media, it follows van Hiele's theory to be adapted to the stages of students' thinking about geometry. Based on the results of the validation and field trials, the digital learning media that have been developed meets the valid, practical, and effective criteria for use in classroom learning.

**Keywords**: Digital Learning Media, Geometry Transformation, GeoGebra, Van Hiele

***How to Cite***: Asnawi, M. H., Turmudi, Harini, S. (2022)**.** Development of GeoGebra-Assisted Digital Learning Media for Geometry Transformation Materials based on Van Hiele's Theory. *International Journal on Emerging Mathematics Education, 6*(2), 149-158. http://dx.doi.org/10.12928/ijeme.v6i2.22444

## INTRODUCTION

The purpose of using learning media is to make it easier for students to understand the subject matter (Netriwati dan Lena, 2017). The use of appropriate learning media can support the success of a learning process (Akgul, 2014). Submission of learning materials using media will be more focused, so students are expected to be more interested and active in the learning process.

The development of learning media is currently influenced by the development of increasingly rapid information and communication technology (Isman, 2016). One of them is the development of digital learning media. The development of digital learning media is well utilized by teachers as learning aids because it is flexible (can be used) in the classroom and outside the classroom (Arindiono and Ramadhani, 2013; Sutarno and Muhkhidin, 2013). Several digital learning media models that have developed include learning videos, e-learning, and mobile learning (Martin & Betrus, 2019).

The development of digital media makes research on the development of digital learning media more and more carried out. Several media studies that have been investigated are the development of learning videos (Adkhar, 2009; Agustien, et al, 2018; Apriansyah, 2020; Fadhli, 2015; Farista and Ali, 2018; Hadi, 2015; Irwandani, et al, 2019; Istiqlal, 2017; Kholidin and Hudaidah, 2017; Purwanti, 2015; Putri dan Muzakki, 2019; Saminanto, 2011; Wisada, et al, 2019), development of e-learning learning media

*Received December 11, 2021; Revised February 2, 2023; Accepted July 1, 2023*

(Andayani, 2015; Okra & Novera, 2019; Yazdi, 2012), and development mobile learning-based learning media (Amirullah and Hardinata, 2017; Astuti, et al, 2017; Dasmo, et al, 2017; Ibrahim and Ishartiwi, 2017; Khomarudin and Efriyanti, 2018; Listyorini, 2013; Nugroho and Purwati, 2015; Nurhalimah, et al, 2017; Power, 2015; Purnama, et al, 2017; Setiawati, et al, 2012; Surahman and Surjono, 2017; Wirawan and Ratnaya, 2011; Yuniati, 2012).

In the field of mathematics, one of the objectives of developing learning media is to improve student achievement. Some mathematics material at the high school level is presented in an abstract manner. So that many students have not been able to understand the material (Akbar, et al, 2017; Jamal, 2014). The advantage of using learning media in mathematics is that it can help visualize abstract material.

One application that can help describe abstract concepts from mathematics is GeoGebra (Khalil, 2016). GeoGebra application is an application that can be accessed by anyone with its features including algebra, calculus, and geometry (Hohenwarter & Preiner, 2007). Geogebra is easy for teachers to use to describe the concepts being taught flexibly. In geometry learning the teacher can describe geometric shapes easily with the help of GeoGebra. This makes it easier for students to grasp the understanding of abstract concepts from geometric material.

With the help of van Hiele's theory in the learning process of geometry. It is expected that students are able to learn in a structured way about the concept of geometry. Van Hiele's theory has proven to be able to help students in instilling geometric concepts. This is evidenced by the many studies on geometry learning in accordance with van Hiele's theory (Abdussakir, 2009; Fitriati & Sopiana, 2015; Kusnadi & Nanna, 2018; Nopriana, 2015; Romika & Amalia, 2014; Safrina, et al, 2014; Sholihah & Afriansyah, 2017). According to van Hiele, students progress in geometric thinking through five successive and hierarchical stages. Students think geometry through one stage to another (Safrina et al., 2014). The five stages consist of visualization, analysis, informal deduction, formal deduction, and rigor (Mason, 1998). The thinking of students who get learning according to van Hiele's theory will be more focused than conventional learning.

The purpose of this research is to develop a digital learning media assisted by GeoGebra on geometry transformation material based on van Hiele's theory. The product developed is a valid, practical and effective learning media application to assist students in learning geometry, especially in the subject of geometry transformation.

## RESEARCH METHOD

The type of research used is research and development (R&D). The purpose of this research is to develop a digital learning media product. The research and development model used is the ADDIE model. This model is used because the development design is dynamic and flexible for the development of digital learning media. Martin and Betrus (2019) stated that this model is very simple and has a general nature, so it is more flexible to be applied in research and development of digital learning media. This model consists of 5 stages of development, namely analysis, design, development, implementation, and evaluation. This development model is used more optimally because researchers evaluate each stage of its development as shown in Figure 1. In developing this learning media, researchers use several application assistances, including Notepad++, GeoGebra, Android Studio, and Ispring Quizmaker. The results of this study are digital learning media in the form of android applications and websites. The learning material is in the form of geometric transformation. The arrangement of learning media has been adjusted to the students' thinking ability following van Hiele's theory.

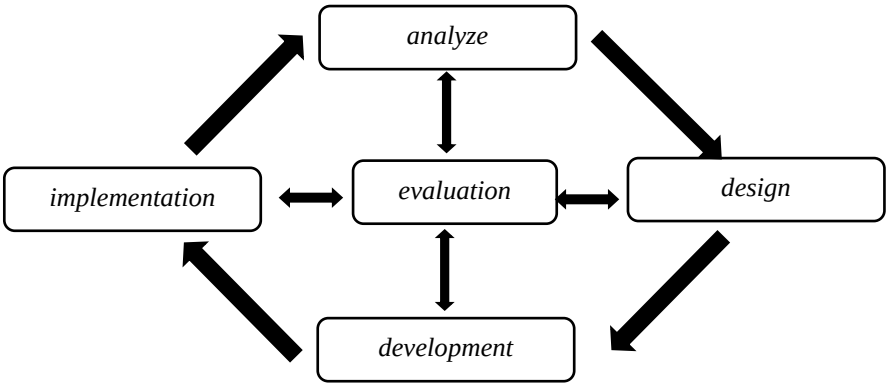


**Figure 1**. ADDIE Development Model

## RESULTS AND DISCUSSION

### Analysis

At this stage, the researcher conducted interviews with two mathematics teachers. The results of the first interview showed that students had difficulty in understanding the material of geometric transformation. This can be seen from the results of students' tests in the geometry transformation chapter. One of the causes of students' lack of understanding of the material is due to the lack of visualization of the given geometry transformation material. The learning process carried out by the teacher has not utilized learning media and only focuses on the available textbooks. The GeoGebra application has also not been fully utilized. The first teacher said "*I have never used GeoGebra in learning. To describe an object, I use a blackboard*".

Then also obtained data that students are allowed to use cellphones or computers in the learning process. Both tools are used in the learning process if there are teachers who ask students to use them. In learning mathematics, the use of cellphones and computers has not been used optimally. During the Covid-19 pandemic, the two electronic devices were used as a tool to deliver material directly by the teacher through face-to-face using applications such as zoom, google meet, or other applications. In addition, it is also used as a place to provide learning materials that have been prepared by the teacher in the form of files.

### Design

At this stage the researcher prepares all the needs needed to develop digital learning media. The researcher prepares the arrangement of the material displayed on the media product as shown in table 1. In addition, he also prepares a story board for learning media that was developed with the help of power points. The researcher also prepared the design of geometric materials using GeoGebra assistance which the researchers would input into the learning media. In addition, questions that have been entered in the Ispring Quizmaker application are also prepared. And also prepare templates for learning media.

**Table 1**. Design of Learning Media Material Arrangement According to van Hiele's Theory

| No | Theory | Learning Stages | Van Hiele's Theory Stage |
|---|---|---|---|
| 1. | Point Translation | a. Observing the concept of translation in everyday life | Visualization |
| | | b. Identify the concept of point translation presented | Analysis |
| | | c. Identify point translations based on the understanding obtained from observations | Informal deduction |
| | | d. Determine the general formula for point translation based on point observations | Formal deduction |
| 2. | Line Translation | a. Identify the concept of line translation presented | Analysis |
| | | b. Identify and determine the general formula for line translation based on observations | Informal and formal deduction |
| 3. | Field Translation | a. Identify the concept of translation of the presented field | Analysis |
| | | b. Identify and determine the general formula for plane translation based on observations | Informal and formal deduction |

## Development

The digital learning media development stage was developed using the Android Studio and Notepad++ programs. The researcher compiled the data that the researcher had prepared previously at the design stage with the help of Notepad++. The results of this stage are digital learning media with website and android application formats. Furthermore, the display of digital learning media is presented in Figure 2.

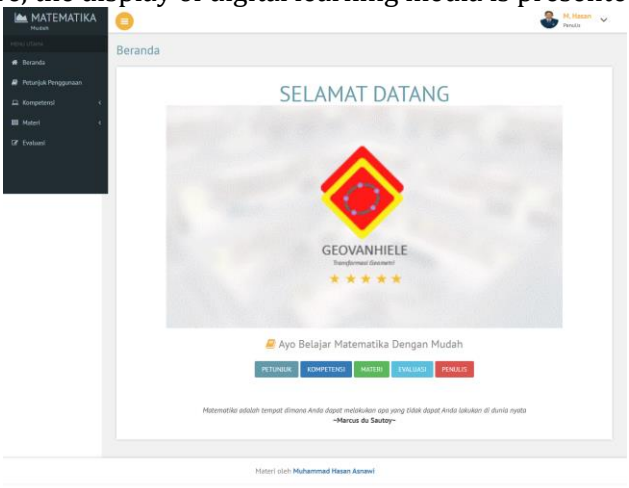


**Figure 2**. Home Page

The home page is the front view of the digital learning media that has been developed (see in Figure 2). This display contains several menus including instructions for use; core competencies and basic competencies; theory; evaluation; and profile.

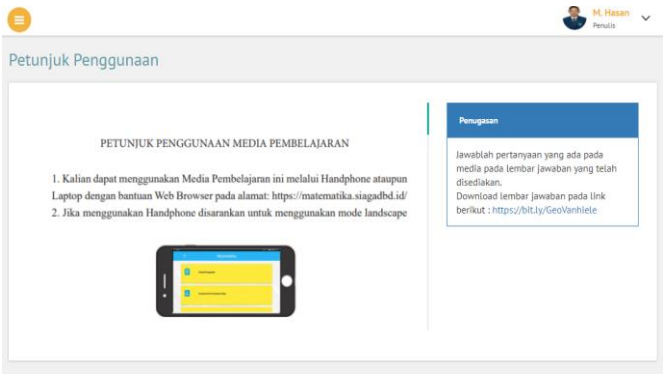


**Figure 3**. Instructions for Use

Instructions for use contain steps for using learning media. This is to facilitate students in the learning process (see in Figure 3). Students are expected to read the instructions for using the media before entering the learning material.


**Figure 4**. Core Competencies and Basic Competencies

Figure 4 contains two competencies achieved by students, namely basic competencies, and core competencies in learning geometry transformation. These two competencies are used as a reference for the content of the material presented in the learning media.

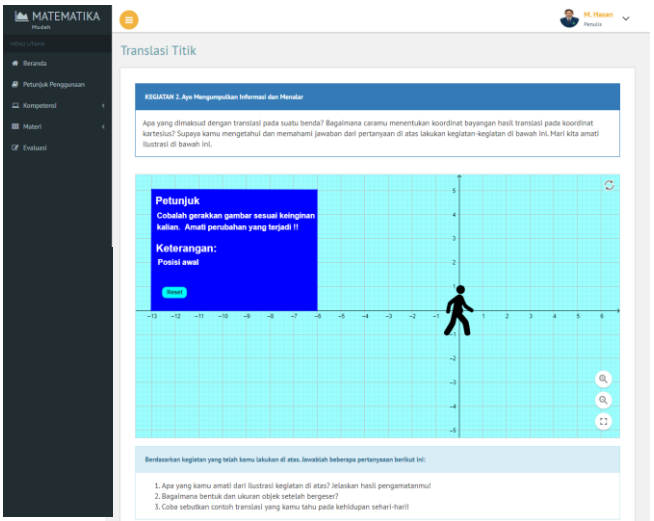


**Figure 5**. Geometric Transformation Material

Figure 5 is an example of displaying material on digital learning media. The material is arranged according to the students' geometric thinking stages according to van Hiele's theory. At the end of the lesson, students are presented with evaluation questions to see the results of the learning that has been done by students.

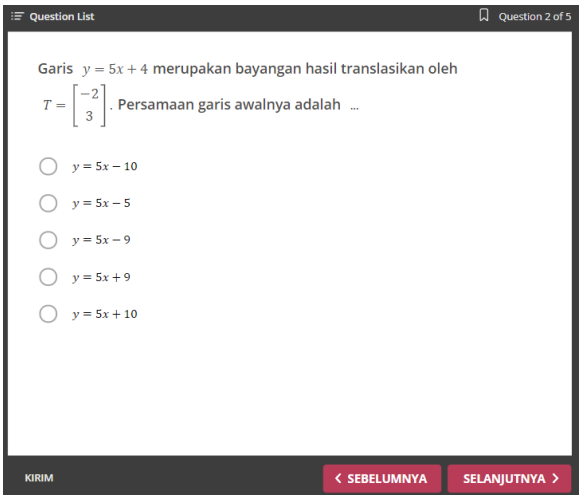


**Figure 6**. Evaluation Questions

In Figure 6, there are final-stage evaluation questions to measure student understanding. In the initial display of the evaluation there is a student identity menu. Furthermore, the next display is the instructions for using the evaluation and continued with some questions. Evaluation activities using the Ispring Quizmaker Software. The results of student evaluations will be automatically sent to the researcher's email, making it easier to conduct an assessment.

## Evaluation

Evaluation activities have been carried out since the beginning of the research carried out to obtain valid, practical, and effective learning media results. The input that has been given by the supervisor is used as one of the evaluations in the development of digital learning media. Furthermore, evaluation activities after the development stage are

carried out during the validation of learning media to media experts, material experts, learning experts, and practitioners. At the implementation stage, the evaluation is carried out after the learning media is tested on students. The results of the evaluation conducted by the experts are presented in Table 2.

**Table 2**. Learning Media Validation Results

| No | Validator | Average Percentage | Description |
|---|---|---|---|
| 1 | Media Expert | 90% | Very Valid |
| 2 | Material Expert | 90.62% | Very Valid |
| 3 | Learning Expert | 91.25% | Very Practical |
| 4 | Practitioner | 88, 28% | Very Practical |

In table 2, the validation carried out by researchers to media experts got 90% results with very valid information. Aspects assessed by media experts include content, structure, navigation, and overall features of digital learning media. The results of validation to material experts get a value of 90.62% with very valid information. Aspects assessed by material experts include the presentation of the material, language and the level of text readability. Then, the results obtained in the validation carried out to learning experts were 91.25% with very practical information. Aspects assessed by learning experts include media content, material presentation, language and text readability, and evaluation questions. Finally, the results of the validation carried out on practitioners obtained a value of 88.28% with very practical information. The aspects assessed by him are media content, median structure as well as navigation and function. From the validation results that have been carried out, it can be concluded that the digital learning media that have been developed are valid and practical.

Evaluation of learning media at the implementation stage was obtained from the results of field trials conducted at two high school schools in the city of Malang. The results obtained from the questionnaire given to students were 84.43% with quite effective information. Aspects assessed by students include media content, media structure, navigation and function, as well as the overall features of digital learning media. While the value of the results of the evaluation carried out by students was 77.08% and 83.77%. Student learning outcomes have exceeded the minimum completeness criteria KKM that has been determined. So, it can be concluded that digital learning media is effective for use in learning.

## CONCLUSION

The results of the development of digital learning media assisted by GeoGebra on geometry transformation material based on van Hiele's theory are in the form of android applications (.apk) and websites that can be used on mobile phones or computers. The results of the learning media validity test conducted by media experts got a value of 90% and the value of the material expert test results was 90.62%. While the practicality test conducted by learning experts got a score of 91.25%, and practitioners got a score of 88.28%. To test the effectiveness of this learning media, it is declared effective to use. So, it can be concluded that overall, this learning media is suitable for use in learning mathematics on geometry transformation material.

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