AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 12, No. 3, 2023, 3481-3493

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i3.7540

GEOMA (*GEOMETRI MATEMATIKA*) APPLICATION AS GEOGEBRA-BASED LEARNING MEDIA TO TRAIN SPATIAL ABILITY

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Received 09 April 2023; Received in revised form 16 August 2023; Accepted 26 September 2023

Abstract

The problem on this research is the low spatial sense ability in geometry material. Students have difficulty transforming literacy into geometric shapes. Thus, it required learning media to support the students in learning the geometry material. This research aims to develop GeoGebra-based mathematics learning media to practice spatial sense ability in geometrical materials for senior high school level practically, effectiveness, and feasibility. This research and development used the ADDIE development model. It covered analyzing needs, designing, developing, implementing the product, and evaluating at each stage. The final result of the development of this learning media is the GEOMA application that has a level of practicality, effectiveness, and feasibility with the category **"good"** to be used as a medium of learning high school geometry.

Keywords: GeoGebra, geometry, spatial sense ability

Abstrak

*Latar belakang penelitian ini adalah rendahnya kemampuan spatial sense pada materi geometri. Siswa kesulitan mentransformasi dari bentuk literasi ke bentuk geometrinya, sehingga dibutuhkan sebuah media pembelajaran yang dapat memudahkan siswa mempelajari materi geometri. Penelitian ini bertujuan mengembangkan media pembelajaran matematika berbasis GeoGebra untuk melatih kemampuan spatial sense pada materi geometri SMA yang layak, praktis, dan efektifitas. Penelitian dan pengembangan ini menggunakan model pengembangan ADDIE. Tahapan penelitian yang dilakukan yaitu menganalisis kebutuhan produk, merancang, mengembangkan, uji coba penggunaan produk, dan evaluasi di setiap tahapannya. Hasil akhir dari pengembangan media pembelajaran ini adalah aplikasi GEOMA yang memiliki tingkat kepraktisan, efektif, dan kelayakan dengan kategori "**baik**" untuk digunakan sebagai media pembelajaran geometri SMA.*

***Kata kunci**: GeoGebra, geometri, kemampuan spatial sense*

INTRODUCTION

Education is a process that helps humans learn, so that the results of the process can be used in dealing with certain problems (Nababan, 2020). Mathematics is fundamental to the advancement of modern technology and the creation of human thinking, and plays an important role in otxher disciplines (Raharjo et al., 2023). Therefore, the ability to do mathematics is very influential for life in the future.

Based on observations related to mathematics lessons made to high school students in Banten Province, show that a positive attitude towards

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i3.7540

mathematics has begun to emerge, which is indicated by the presence of several students who like mathematics and consider mathematics as one of the challenging subjects.

One of the materials in mathematics is geometry, which is taught at every level of education starting from elementary school education to college. Geometry lessons have a greater chance of being understood by students, in addition to geometry ideas already known by students from elementary school, it turns out that almost all visual objects that exist around students are geometry objects. But in reality, geometry material still makes many students feel difficulty. This was revealed through discussions with several students related to learning geometry which results show that they think geometry is a math lesson whose material is difficult, requires focus, and there are many stages in solving it. Students assume that to solve geometry problems they need to memorize many formulas and they also think that geometry lessons tend to be difficult to understand because they take a relatively long time. Geometry material not only requires students to understand the concept, but students must also be able to visualize the geometric objects in the problem.

Student difficulties are also caused by several things, namely the lack of understanding of students on the concepts and properties of geometry, lack of understanding of previous material, and lack of skills to use geometry ideas to solve math problems (Sholihah & Afriansyah, 2017). Kariadinata in Japa (2017), revealed many geometry problems that require visualization. This shows that students' mathematical spatial abilities are still low.

Spatial ability known as perceptual-visual ability, refers to the an individual's ability to understand, interpret, and manipulate information related to objects and the space around them (Teapon et al., 2023). Based on research of Putri et al. (2016), the low spatial ability can also be caused by the lack of students understanding about geometry concepts, as well as the lack of practice problems so that students' problem-solving skills become less. In developing spatial abilities, innovative media is needed to make it easier to visualize geometric shapes (Raharjo et al., 2023). In addition, to teach abstract mathematics, it needs to be visualized in concrete form (Sumargiyani & Yanto, 2020).

Technology has become one of the learning resources used in the current era. In the Industrial Revolution 4.0, digital media is growing rapidly, various kinds of advanced technology have developed such as Android applications. The rapid development of technology at this time can be utilized to develop the world of education (Aprillia & Zainil, 2020). One technology that is very interesting to develop in an educational context is Geogebra which allows teachers to create a dynamic and visual learning environment, giving students the opportunity to explore mathematical concepts in an interactive way (Soeprianto et al., 2023). With its various facilities, Geogebra can be used as a mathematics learning media to demonstrate or visualize mathematical concepts and as a tool for students to construct mathematical concept (Rohim et al., 2023). In addition, the animation feature on Geogebra can be used to expose more concrete constructions that make it easier for students to identify the characteristics of geometry objects with direct visualization (Sirad & Arbain, 2021).

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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This is in line with Khairunnisyah (2022) research, where Geogebra-based learning media can be used in learning high school mathematics. The use of Geogebra-based teaching materials also improves learning outcomes compared to conventional methods (Amri, 2018). In addition, Ayuningtyas et al. (2018), also explained that the output files from GeoGebra are commonly called Geo-Gebra Applets which can be used, modified, and developed by educators to make it easier for students to under-stand mathematics more dynamically and interactively.

Therefore, it is necessary to develop GeoGebra-based mathematics learning media to practice spatial sense ability in geometrical materials for senior high school level practically, effectiveness, and feasibility. The developed learning media acts as a tool to visualize and construct geometry concepts so as to facilitate students in understanding the three-dimensional material that requires a visual display and can have positive implications for student learning outcomes whether used on smartphones or on laptops.

RESEARCH METHOD

The research method used is Research and Development (R&D) because it aims to produce a product in the form of GEOMA application as GeoGebra-based learning media to train students' spatial sense ability in high school geometry material. This research uses the ADDIE model which provides opportunities for evaluation at each stage. This is done to maximize the product developed and minimize the shortcomings or errors of product development from the initial stage to the final stage of this research model.

The subjects in this study consisted of 3 material experts, 3 media experts, 3 responses from mathematics teachers who taught in class XII, and 28 students of SMAN 1 Ciruas Banten Province class XII IPA. The sampling technique used in this study was cluster random sampling by means of a single stage cluster. Where the researcher chose class XII IPA 4 with a total of 28 students consisting of 10 male students and 28 female students.

The procedure in this research consists of five stages of development. The first is the analysis stage, which is an effort to analyze the development needs and feasibility of development requirements. The next stage is the design stage. This design stage starts from the selection of media that will be used in the learning media development process, material assessment, initial design in the form of an overview both in terms of material and appearance of the learning media to be developed, as well as designing research instruments. Then the development stage or product realization stage is a follow-up to the product design stage developed. The media development stage starts from making learning media, application feasibility validation, application revision, and practicality testing. After the product is improved, the next stage is the trial stage. This implementation was carried out to 28 students of SMAN 1 Ciruas class XII, the questionnaire used was given after students used the media, besides that students were also given questions related to spatial sense ability to determine the effectiveness of the media. The evaluation stage is a process to analyze the media at each stage of the research.

This research uses several research instruments consisting of material and media expert validation

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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instruments given to 3 experts in each field, teacher and student response instruments given to 3 teachers and XII grade students at SMAN 1 Ciruas Banten Province, and spatial sense ability test instruments.

After the validation data from experts, teacher responses, and student responses, as well as the results of the required spatial sense ability test, were collected, the researchers conducted data analysis. Quantitative data were obtained from expert validation assessments, teacher and student responses, and spatial sense ability test results. This quantitative data analysis aims to determine the feasibility, practicality, and effectiveness of the developed media. Where the instrument uses a likart scale consisting of strongly agree, agree, moderately agree, disagree, and strongly disagree using the score category from (Sugiyono, 2019). We can see the assessment categories in table 1.

Table 1. Assessment score category

Rating Category	Score
Very agree	5
Agree	4
Pretty agree	3
Not agree	2
Not very agree	1

The Likert scale formula is presented in equation (1) below. Then, the scale category values are presented in Table 2.

$$P_k = \frac{S}{N} 100\% \ldots (1)$$

Description:
P_k = Worthiness category value
S = Total score obtained
N = Ideal number of questions

Table 2. Assessment percentage categories

Rating Category	Score
Very good	81%−100%
Good	61%−80%
Pretty good	41%−60%
Not good	21%−40%
Not very good	0%−20%

The completeness of effectiveness is seen from the Minimum Completeness Criteria (KKM) set by the school concerned. The KKM for mathematics that has been set by SMAN 1 Ciruas is 75. To calculate the percentage of classical completeness, the formula in equation (2) can be used.

$$p = \frac{L}{n} \times 100\% \ldots (2)$$

Description:
p = Percentage of classical completeness
L = Number of students who passed the KKM
n = Number of students

The percentage of completeness can then be categorized according to the assessment criteria by (Widoyoko, 2009) presented in Table 3.

Table 3. Criteria for percentage of completion of spatial sense ability

Criteria for Completion	Score
Very good	$p \geq 80$
Good	$60 < p \leq 80$
Pretty good	$40 < p \leq 60$
Not good	$20 < p \leq 40$
Not very good	$p \leq 20$

Qualitative descriptive analysis is used to process data from observations, questions and answers, as well as responses or input from experts. The qualitative analysis step starts from collecting data from observations and questions and answers to students

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

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regarding learning activities, along with supporting factors, obstacles, and student difficulties during learning, as well as responses or input given by experts to the media developed. Then data reduction, data presentation, and conclusions from the data obtained are the answers to the problem formulation of the research conducted.

RESULTS AND DISCUSSION

GEOMA application is a GeoGebra-based math learning application that contains three-dimensional geometry material to train the spatial sense ability of XII grade high school students. The following is the explanation of the results of research that has been done:

Analyze Stage

The analysis consists of curriculum, student needs, and student characteristics. SMAN 1 Ciruas, using the Curriculum 2013 with the scientific approach which the teaching and learning activities in groups. Curriculum 2013 requires teachers to combine learning with the help of technology. Analysis of the characteristics showed that students bored doing the same activity for a long time. Besides, to understand math takes a long time if left, it will hinder further materials. The visual media allows students to learn geometry.

Based on curriculum analysis, student characteristics, and needs, the researcher developed GeoGebra-assisted mathematics learning media to train spatial sense skills in the third dimension at the XII grade high school level. The learning media to be created acts as a tool to visualize and construct geometry concepts. In addition, the media developed display explorative visualization and be more interactive to facilitate students to understand the material of the third dimension that requires a visual display and can have positive implications for student learning outcomes. This media can be accessed by students through computers or smartphones so that it can facilitate students in practicing spatial sense in the third dimension material.

Design Stage

The design phase started by selecting the media, GeoGebra software, Adobe Illustrator, Microsoft PowerPoint, and Web 2 Apk v3.4. used on this media. This research uses several research instruments consisting of material and media expert validation instruments given to 3 experts in each field, teacher and student response instruments were given to 3 teachers and 28 XII grade students at SMAN 1 Ciruas Banten Province, and spatial sense ability test instruments.

In addition to the questionnaire research instrument in the development of this learning media, there is also an instrument of spatial sense ability on three-dimensional material. Each instrument sheet has been approved by the supervisor.

The references are sourced from the 2013 Curriculum Class XII Student Mathematics Book published by the Ministry of Education and Culture and GeoGebratube.org as the references to develop the GEOMA application. The GEOMA (Geometri Matematika) Application consists of some 29 views among main display, home, three-dimensional materials, exercises, evaluations, motivational sentence, questionnaire response of students, and the identity of the developer.

The Flowchart of the GEOMA application developed can be seen in Figure 1.

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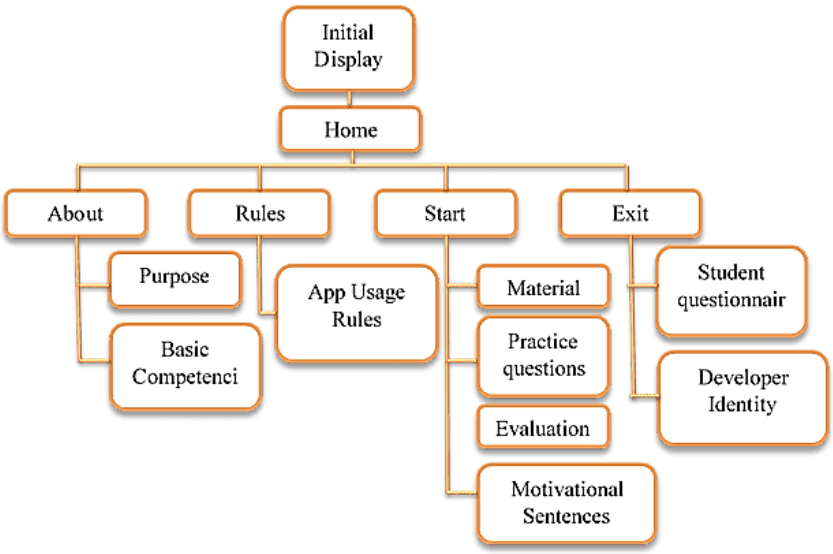

Figure 1. Flowchart of the GEOMA application

Development stage

The stages of developing the GEOMA application are as follows:

A. Making The GEOMA application

First, created GeoGebra applets, and then created the application using the Web 2 APK v3.4.application. The following is several the view of the GEOMA application developed by the researcher. The initial main view of the Geoma App can be seen in Figure 2.

Figure 2. Initial display.

On the home menu there are several options including about, rules, start, and exit. This home display or menu is also the main display that can provide information about this GeoGebra-based learning media. We can see the home display in Figure 3.

Figure 3. Home menu

When we click on the start menu, we can learn the material of the third dimension, practice questions, do evaluation questions, and motivational sentences to increase student motivation. The third dimension material can be seen in Figure 4.

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Figure 4. The third dimension material

B. Validation of GEOMA Application Feasibility

It aims to find out that the GEOMA application is feasible to use. The validation of the material experts was assessed by 3 experts, Mr. Ihsanudin, M. Si., Mr. Sukirwan, M. Pd., and Mr. Maman Fathurrohman, Ph.D. (Lecturer in Mathematics Education Untirta). The validation of the media experts was assessed by 3 experts, Mr. Aan Subhan Pamungkas, M. Pd., Mrs. Isna Rafianti, M. Pd., (Lecturer in Mathematics Education Untirta), and Mr. Thoha Nurhadiyan, M. Kom. (Lecturer at Serang Raya University). Material and media experts validations obtained 81.7% and 85% were in excellent qualifications. Material and media expert validation assessment result can be seen in Table 4 and 5.

Table 4. Material expert validation assessment results

Number	Aspect	Indicator	S	N	Percentage (%)
1.	Content feasibility	The suitability of the material with KI and KD	36	45	80
		The accuracy of the material	86	105	81,90476
		Supporting learning material	74	90	82,22222
		Up-to-date content	26	30	86,66667
2.	Feasibility of Presentation	Presentation Techniques	36	45	80
		Presentation	48	60	80
Final Percentage					**81,7989418**

ISSN 2089-8703 (Print)
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Table 5. Media expert validation results

Num.	Aspect	Indicator	S	N	Percentage (%)
1.	Coloring	Appropriateness	37	45	82,22222
2.	Use of Words	Sentences Appropriateness of Language	61	75	81,33333
3.	Graphics and Design	Image Quality	63	75	84
4.	Learning	Media Appropriateness	28	30	93,33333
5.	Curriculum	Material Appropriateness	38	45	84,44444
Final Percentage					**85,06666667**

C. Revised GEOMA Application

After the material and media experts validated the product, then the researchers revised it. Corrections and suggestions from material experts are as follows:

- The definition of diagonal needs to be improved again to make it more clear.
- The appearance of the material is not clear with the basic color.

The display before revision can be seen in Figure 5. And The display after revision can be seen in Figure 6.

Figure 5. Display before revision

Figure 6. Display after revision

Corrections and suggestions from media experts are as follows :

- We recommend that you add a backsound.
- The design colors are not eye catchy, too colorful when presenting the material
- The initial background is rather dark.
- It would be nice if the existing Button was explained so that it is not empty.
- The font is slightly enlarged to make it easier for users to understand.

The display before revision can be seen in Figure 7. And The display after revision can be seen in Figure 8.

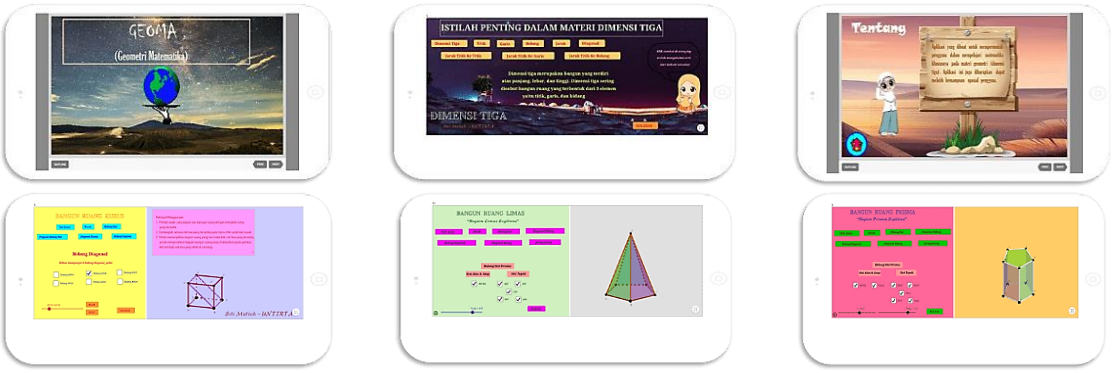

Figure 7. Product display before revision

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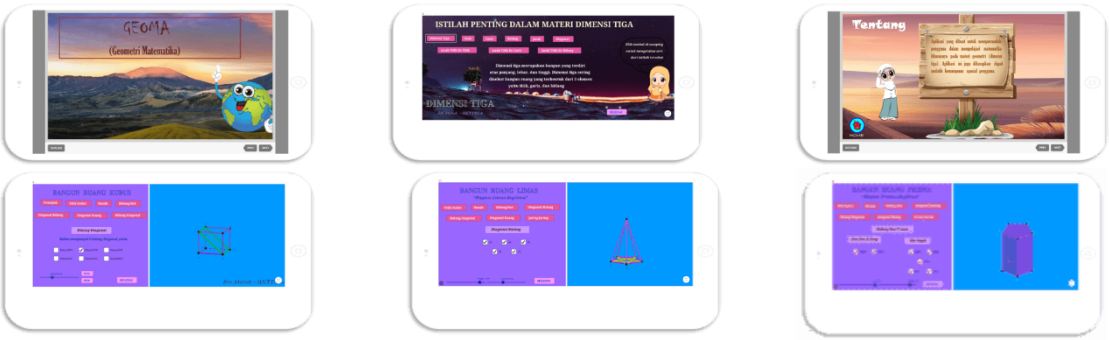

Figure 8. Product display after revision

D. Mathematics Teacher Response

The results of the assessment of the response of 3 Mathematics class XII teachers obtained 81.8% with excellent practical qualifications.

E. Student Responses

On Tuesday, April 7, 2020, the online trial through the WhatsApp group, it helped by the home room teacher of XII IPA 4. Video instructions can be watched in *bit.ly/Geoma_UsageVideo*. 28 students' responses indicated that the application qualified excellent practicality by 81%. It based on the assessment of the students' responses consisted of aspects of media operation and user reactions. It can be seen in Figure 9.

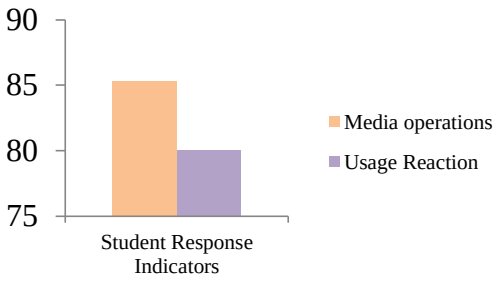

Figure 9. Student response results

The assessment response of students on aspects of media operations classified very well. It showed that the GEOMA application is easy to use to support the learning process.

Implementation Stage

The product trial phase in this study is as follows:

The Results of the Spatial Sense Ability Test

The tests conducted to determine the effectiveness of the learning media that have developed. The results of the spatial sense ability test obtained an average of 71. The effectiveness of the media consisting of 5 essay questions obtained 64.2% graduation in the effective category. Indicators and assessment rubrics on spatial sense ability follow the criteria of (Fajri et al., 2016) with a maximum score of 4 and a minimum of 1. Where the indicators are as follows:

- Indicator 1, stating the position between the elements of a building space.
- Indicator 2, identify and classify geometry images.
- Indicator 3, imagine the shape or position of a geometry object viewed from a certain point of view.
- Indicator 4, construct and present geometry models drawn on a flat plane in the context of space.
- Indicator 5, investigate a geometry object with rating scale.

The results can be seen in the Figure 10.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i3.7540

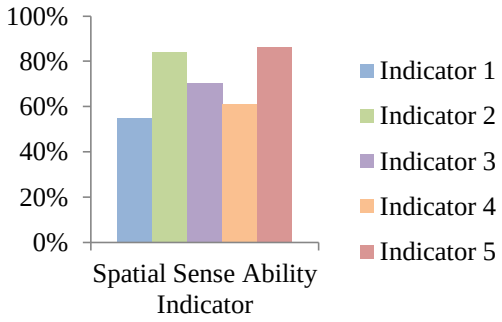

Figure 10. Recapitalization of achievement indicators

The lowest achievement is in the indicator states the position between the elements of building space by 55%. The weakness caused by students having difficulty in describing the position between the elements of building space. Besides, they are also not accustomed to visualizing mathematical problems. In line with the connectionism learning theory proposed by Thorndike, that repetition or practice can help and strengthen students' understanding of the material.

The students' ability to construct and present geometry models achieved better by 61%. It indicated that students can visualize based on the description provided. The visualization helps to understand the mathematical problems concretely. The achievement of indicators imagines the shape or position of an object seen from a perspective of 70%. It indicated that students can imagine and visualize based on the information provided.

The highest achievement obtained in the indicators to identifying and classifying geometric images and investigating the geometry object, by 84% and 86%. Students accustomed to getting formulas and memorizing them. As a result, memorizing and counting better than understanding concepts. In general, student mastery of three-dimensional material using the GEOMA application is good. During the learning process, students directed to build their knowledge.

GEOMA application to train spatial sense ability is suitable for students to use as a learning media that utilizes technology. This is based on validation from material experts and media experts obtaining an assessment of 81.7% and 85% in the very valid category.

Teacher and student response assessments get a percentage of 81.8% and 81% in the very practical and easy to use category, where students can download this application at *bit.ly/GEOMA_GeometriMatematika* then install it on their respective android. Apart from the application form, a GeoGebra applet is also provided which can be downloaded to be studied on a laptop or computer offline. For instructions on how to use the media, a video is provided at *bit.ly/VideoPenggunaan_GEOMA.* This is in line with the opinion of Wulandari et al. (2023), one of the benefits of media in the learning and learning process is to facilitate interaction between teachers and students so that learning activities will be more effective and efficient. besides that, the ability to obtain and use media is also very useful for facilitating student learning. This is also in line with research from Rosyana et al. (2023), where with the use of Geogebra software users feel helped in constructing abstract mathematical concepts, visualized, to obtain a conclusion and mathematical problems.

And the spatial sense ability test results obtained an average of 71 with a classical completeness of 64.2% in the effective category. During the learning process students are directed to build their own knowledge. This is in line

ISSN 2089-8703 (Print)
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with the theory of constructivism that knowledge is acquired by students for themselves and transferring complex information into simple ones. By building their own knowledge, the knowledge gained becomes a solid foundation for building the next knowledge.

In addition, the results of spatial sense ability also show that the average male student is better than female, which is 78 and 67. This is in line with the research of Ashari (2014), which explains that there are significant differences in the spatial abilities of male and female students. In addition, research Asis et al. (2015), also explains that in solving geometry problems male students are more dominant in using their spatial abilities.

The development of GeoGebra-based learning media with the final product in the form of GEOMA applications has the following advantages:

1. GeoGebra-based learning media can be used on android smartphones and laptops.
2. Learning becomes more interesting and not boring, because learning media is made with language that is easy to understand.
3. The media is easy to use because the instructions for use are easy to watch at *bit.ly/VideoPenggunaan_GEOMA*
4. The existence of pictures and illustrations makes this GEOMA application can increase the enthusiasm and motivation of students in learning math.
5. Learning media can make it easier for students to understand geometry material.
6. In this learning media there are sample problems and tests of spatial abilities that can test students' understanding of geometry material.

Beside that, the disadvantages of the application are:

1. This learning media has a limitation, which is only for three-dimensional geometry material only, so the need for renewal of the content of the material and design in accordance with the needs of the study.
2. The lack of insight and information obtained in the research that has been done, there needs to be further study of GeoGebra-based learning media.
3. The learning media developed with the final product in the form of the GEOMA application still has limitations in appearance, for future research is expected to provide more interactive options for students with the developed media.

CONCLUSION AND SUGESTION

Based on the results of research on the development of GeoGebra-based mathematics learning media to train spatial sense abilities on three-dimensional geometry material, it can be concluded that research with the ADDIE model (Analyze, Design, Development, Implementation, and Evaluation) produces a final product in the form of GEOMA applications. Validation assessment from material experts and media experts obtained an assessment of 81.7% and 85% which is in the category of "very valid". The assessment of teacher and student responses obtained a percentage of 81.8% and 81% which were in the "very practical" category, and the results of the spatial sense ability test conducted by 28 students consisting of 18 female students and 10 male students obtained an average of 71 with classical completeness of 64.2% in the "effective" category. Based on the description above, the development of GeoGebra-based mathematics learning

ISSN 2089-8703 (Print)
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media to train spatial sense skills in high school geometry material can be used as a feasible, practical, and effective mathematics learning media to be used in mathematics learning.

In the next researches, GeoGebra-based mathematics learning media to train spatial sense abilities in geometry material can be a reference for future researchers as an initial research picture. This learning media also has a limitation, which is only for three-dimensional geometry material only, so there needs to be an update of the material content and design according to research needs. The lack of insight and information obtained in the research that has been done, there needs to be further study of GeoGebra-based learning media.

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ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i3.7540

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