Journal of Instructional Mathematics
E-ISSN 2722-2179
DOI: 10.37640/jim.v6i1.2341
Volume 6, Issue 1; 2025

Design of 6E-Instructional Model Assisted by GeoGebra Media in Improving Students' Mathematical Visual Spatial Ability on the Topic of Prism

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Article Info

Received
April 7, 2025

Revised
June 26, 2025

Accepted
July 21, 2025

Keywords

6E-Instructional Model; Geogebra; Prism; Visual Spatial.

Abstract

Students' mathematical visual-spatial ability is crucial for understanding geometry. However, its suboptimal level calls for quality learning. The purpose of this study was to test the quality of the Geogebra-assisted 6E-Instructional Model (6E-IM) on students' spatial visual ability; test the effect of Geogebra-assisted 6E-IM on spatial visual ability; and describe students' spatial visual ability after receiving the Geogebra-assisted 6E-IM model. This study used an embedded design. The Geogebra-assisted 6E-IM model (independent variable) was measured through interviews, while spatial visual ability (dependent variable) was assessed using questionnaires. The results showed that the geometry learning instrument with the 6E-IM learning model assisted by Geogebra was in the very good category with a score of 92%, and positively affected students' visual-spatial abilities. Description of students' spatial visual ability involving 2 students in each category, in the high category, met all indicators of spatial visual ability; students with moderate spatial visual ability met two indicators of spatial visual ability; and students with low spatial visual ability met one indicator of spatial visual ability. The results of this study are expected to be Geogebra integrated 6E-IM Design can be used by teachers to improve students' visual spatial abilities.

How to Cite:
Prasetya, N., Sembiring, M. G., Sudirman, S. (2025). Design of 6E-Instructional Model Assisted by GeoGebra Media in Improving Students' Mathematical Visual Spatial Ability on the Topic of Prism. *Journal of Instructional Mathematics*, *6*(1), 72-83.

INTRODUCTION

Students' spatial visual ability is one of the key factors in learning geometry, especially in understanding plane and spatial shapes (Kondor, 2016; Atman Uslu et al., 2022). However, many students face difficulties in developing this spatial visual ability. This can be seen from their inability to visualize and imagine geometric objects, which ultimately hinders their understanding and learning achievement (Lowrie et al., 2019). Sudirman and Alghadari (2020) added that spatial ability consists of two main components: spatial orientation and spatial visualization. It is expected that by developing spatial visualization skills, students can easily solve problems in geometry.

This spatial visual ability plays a role in understanding the relationships and characteristics in geometry, which will ultimately help students in solving mathematical problems (Suwito et al., 2016). Difficulties often arise in geometry topics such as prisms, where students need to understand the relationships between the elements of spatial shapes. According to research conducted by Aprilia et al. (2024); Sudirman et al. (2024) many students experience difficulties in understanding abstract geometric concepts, especially related to spatial shapes. This difficulty is reinforced by the findings of Rizki et al. (2022) which revealed that students have difficulty in distinguishing and identifying the elements of spatial shapes. This difficulty hinders students' learning to understand a material. Because, students are not given the opportunity to explore because learning still uses conventional methods. Therefore, a method is needed to support students' ability to understand the topic of geometry.

In general, low students' spatial visual abilities is a phenomenon that is often found at various levels of education. Research conducted by Manik et al. (2024); Sari et al. (2025) and Sudirman et al. (2023) shows that limited spatial visualization can hinder the development of geometric understanding in elementary to secondary school students. This is exacerbated by learning approaches that tend to be monotonous and less interactive, so that students do not get enough opportunities to develop their spatial visual abilities. In the context of mathematics learning, the importance of learning media that support visualization has been widely emphasized by experts.

Based on the results of observations and interviews with several students in the odd semester of the 2023/2024 Academic Year, it was revealed that three out of ten students had no interest in learning mathematics, especially materials involving visual abilities. The results of field observations showed that the mathematical problem-solving abilities of junior high school students, especially class VII-B, were still low. This can be seen from the results of the mid-semester assessment, which showed that only 18% of students achieved the Minimum Completeness Criteria on the the topic of prism. In addition, researchers observed that most students had weak self-control in dealing with mathematics problems by not answering questions and taking a long time to work on them.

One learning model that is expected to be able to improve students' visual-spatial-mathematical intelligence is the 6E-IM learning design. Thus, both models will theoretically encourage mathematical thinking, problem solving, and exploration. The role of teacher guidance was found to be instrumental in augmenting students’ comprehension and application of modeling concepts. The study advocates for the integration of metacognitive prompts within instructional design to enhance learning outcomes and promote autonomous problem-solving capabilities (Huang et al., 2025).

This action research will explore the 6E model and its effectiveness in mathematics classrooms to influence my teaching. In Sudirman (2022) research, it was stated that in mathematics learning, the use of this model has been proven to help students to more easily visualize abstract concepts, such as geometry, which requires good spatial visual skills and there is a research update, namely the learning of the 6E-IM model assisted by GeoGebra. Previous research conducted by

Sudirman et al. (2022) that there is a difference in research, namely the learning media used, in Sudirman's research using Augmented Reality, while the research I did used Geogebra.

Other research by Izzati et al. (2024) The results of the study showed that most students gave a positive response to the use of GeoGebra in spatial geometry courses, with an average percentage of 93.51%, including the strong category and the increase in the spatial mathematical ability of students who used GeoGebra in the spatial geometry course was significantly higher than the improvement of the spatial ability of students who were taught conventionally.

Based on the phenomenon, the urgency of this research is to improve students' spatial visual skills, assisted by the 6E-IM learning model, assisted by Geogebra. The results of this study are expected to help students improve their spatial visual skills to understand three-dimensional geometry lessons.

RESEARCH METHODS

This research uses the 6E-IM learning design. This study uses a mixed-methods approach with a concurrent embedded design. Pane et al. (2021) explain the embedded model combination research method, which is a research method that combines the use of quantitative and qualitative research methods simultaneously (or vice versa). In this embedded model, there is quantitative research as the primary method, while the qualitative method is the secondary method (Hardani & Andriani, 2020).

Quantitative research in this study, using quasi-experiments as a primary will be used to test the research hypothesis and analyze data statistically, while qualitative methods will be used to dig deeper into students' experiences and perceptions related to learning with 6E-IM assisted by GeoGebra, thus providing a more comprehensive understanding of the phenomenon being studied (Creswell & Creswell, 2018)

The population in this study was all 7th-grade students at a junior high school in Kahayan Tengah, Pulang Pisau Regency, Central Kalimantan Province, totaling 90 students. This study used a purposive sampling technique to determine the sample, which consisted of two experimental and control groups, with each group consisting of 30 students. This division was carried out by considering the distribution of students' mathematical abilities based on odd semester grades so that the distribution of students' initial abilities in both groups could be considered balanced.

This research was conducted from January 13 to January 18, 2025. It began with distributing a pretest before starting learning, continued with an explanation of the material, each meeting was given practice questions, and on the fifth day, a questionnaire was given to see the level of students' visual spatial abilities. Continued with a posttest at the last meeting.

Quantitative research begins with the prerequisite test, used is the data normality test. The Shapiro-Wilk normality test is used with a significance level of $\alpha=0.05$ using SPSS 25. This was chosen because the number of samples is less than 50. Continued with the homogeneity test. The homogeneity test used is the Levene test with a significance level of 0.05. Then the last one is the hypothesis test. The independent sample *t*-test will be used to test the research hypothesis (Aprila & Fajar, 2022).

The qualitative research used an exploratory case study approach with interviews and observation techniques (Habibullah et al., 2025). The data obtained from the thesis results were analyzed qualitatively using content analysis. The qualitative data analysis technique used the Miles and Huberman model which consists of three main stages, namely data reduction, data display, conclusion drawing (Sugiyono, 2017).

RESEARCH RESULTS

Other factors that can cause students to experience difficulties can come from external factors, such as the teacher who teaches. Based on interviews that have been conducted, the questions given by the teacher to students have been directed towards problem-solving questions and based on the results of observations, the learning carried out by the teacher has required students to be active and construct their knowledge, but the teacher's follow-up to students who experience difficulties has not been carried out. This causes students who have difficulty solving a problem to continue to experience difficulties if given a similar problem.

The findings are also reinforced by the percentage of students who cannot answer questions correctly. This can be seen in Table 1.

Table 1. Percentage of students who could not answer correctly

No	Question Indicator	Total Students	Students' Answers Incorrect	
			Total	(%)
1	Identify models or objects related to prisms	30	25	83,3
2	Identifying the elements of a prism	30	21	70
3	Breaking down geometric shapes into smaller ones (nets)	30	22	73,3
4		30	21	70
5	Students can determine how to find the surface area of a prism.	30	24	80
6		30	23	76,6
7		30	23	76,6
8	Students can determine how to find the volume of a prism.	30	23	76,6
9		30	25	83,3
10		30	21	70

Source: Pretest results of control class students at a junior high school in Kahayan Tengah.

In Table 1, it can be seen that most students (more than 50%) answered the questions incorrectly. This can be seen in the answers to test item number 1, only 16.7% of students were able to answer the question correctly, and the remaining 83.3% of students answered the test question incorrectly. For test item number 2, only 30% of students answered the question correctly, and the remaining 70% answered the question incorrectly. Furthermore, for test item number 3, only 26.7% answered the question correctly, and the remaining 73.3% answered it incorrectly. In addition, for test item number 4, only 30% of students answered the question correctly, and the remaining 70% answered the question incorrectly. For test item number 5, the number of students who answered the question correctly was 20%, while the number of students who answered the question incorrectly was 80%. For test items 6, 7, and 8, only 23.4% of students answered the question correctly, and the remaining 76.6% of students answered the question incorrectly. In test question number 9, only 16.7% of students were able to answer the question correctly, and the remaining 83.3% of students answered the test question incorrectly. In the last question, 30% of students answered correctly, and the remaining 70% of students answered incorrectly.

If examined more deeply, the large number of students who answered incorrectly indicates that students experience epistemological obstacles in carrying out a series of 3D geometric thinking tasks, for example, in representing 3D geometric objects, determining the spatial structure of 3D geometry, and measuring the surface area and volume of 3D geometry.

GeoGebra-assisted 6E-IM design consists of elicit, engage, explore, explain, elaborate, and evaluate phases. GeoGebra-assisted 6E-IM design considers the Realistic Mathematics Education (RME) learning theory and the use of ICT in geometry learning. In addition, GeoGebra-assisted 6E-IM design is used to teach materials related to (1) determining the elements and properties of triangular prisms, cuboids and cubes; (2) drawing triangular prisms, cuboids and cubes; (3) making nets of triangular prisms, cuboids and cubes; (4) determining the surface area of triangular prisms, cuboids and cubes; (5) determining the volume of triangular prisms, cuboids and cubes.

Expert Validation Limited Testing Overview

The learning device and research instrument were validated by the principal, 2 mathematics teachers, and 1 BK teacher. The recapitulation of the validation results of the research instrument can be seen in Table 2.

Table 2. Recapitulation of learning device validation

Learning Tool	Validator			Description
	1	2	3	
Teaching module	89%	94.5%	92.7%	All learning devices are categorized as “very good”
Student worksheet	90%	91.25%	91.25%	
Pre-test	90%	94%	96%	
Post-test	90%	94%	100%	
Angket kemampuan visual spasial	91.4%	100%	91.4%	
Flexible interview	84%	96%	96%	
Observation sheet	90%	100%	93.3%	

Table 2 shows that all learning devices have very good criteria, so it can be concluded that all learning devices are declared valid, so that they can be used in this study. The instrument was used in the implementation of learning in the experimental group with the 6E-IM model assisted by GeoGebra.

According to the school’s lesson plan, the implementation of learning takes place over seven meetings. Eight meetings for delivering materials and one meeting for evaluation, as shown in Table 3.

The implementation of learning in general has gone well and in accordance with the teaching module that has been created. All learning content at each meeting was delivered and all stages in the 6E-IM model were assisted by GeoGebra, as evidenced by the results of observations at the first and second meetings. The complete observation sheet for the implementation of the 6E-IM model learning assisted by GeoGebra can be seen in the Appendix. The summary of the results of observations of the implementation of the 6E-IM model learning assisted by GeoGebra from the first to sixth meetings can be seen in Table 4.

Table 3. Distribution of materials and meetings

Meetings	Learning Object
Day-1	Identifying the elements and properties of prisms, cuboids, and cubes
Day-2	Making nets for triangular prisms, cuboids, and cubes
Day-3	Calculating the surface area of triangular prisms
Day-4	Calculating the surface area of cuboid and cube prisms
Day-5	Calculating the volume of triangular prisms.
Day-6	Calculating the volume of cuboids and cubes.
Day-7	Evaluation

Table 4 shows that the teacher's ability to manage learning in the first to sixth meetings is categorized as high. Thus, it can be concluded that all learning with the 6E-IM model assisted by GeoGebra was carried out very well.

Table 4. Student learning observation results

Meeting	Average	Implementation Value	Criteria
I	35.63	89.0%	High
II	31.7	79.2%	High
III	32.9	82.2%	High
IV	33.13	82.8%	High
V	32.13	80.3%	High
VI	31.7	79.2%	High

After carrying out the learning stage and working on students' visual spatial ability test questions, students' visual spatial ability test data can be produced. The results of the study used in this sub-chapter are post-test data followed by analysis to obtain conclusions. Before the data is analyzed, the first stage carried out is the data prerequisite test.

For the post-test data, the results of the normality test using the Shapiro-Wilk test assisted by SPSS with a significance level of 0.05 or 5%, it was obtained that the significance value (*Sig.*) of the experimental class was *Sig.*=0.083>0.05=α and the control class was *Sig.*=0.064>0.05=α which means that the visual spatial abilities of students in both classes come from a normally distributed population. The homogeneity test was carried out as a prerequisite in the analysis of the Levene test with SPSS 21.0, the results showed that the Levene test value was more than 5%, namely 0.411. This means that there is no difference in variance between the experimental group and the control group. After the data of both classes are normally distributed and homogeneous, the next step is to test the hypothesis.

Average Test

The results of the data test obtained $t_{count}=5.28>1.699=t_{table}$. The average students visual spatial ability in the 6E-IM model assisted by GeoGebra can reach the KKTP

(*Kriteria Ketercapaian Tujuan Pembelajaran* or learning objective attainment criteria).

Classical Completeness Test

Next, a classical completeness test is carried out to calculate the proportion of completeness of the results of the visual spatial ability test of students who obtained the 6E-IM model assisted by GeoGebra, reaching the minimum learning completeness criteria, namely 75% of all students who achieved the KKTP score. The results of the data test obtained $Z_{count}=1.898>1.645=Z_{table}$, then H_0 is rejected, meaning that the proportion of students' Visual Spatial Ability completion who obtained the student visual spatial ability model in the 6E-IM model assisted by Geogebra achieved classical learning completion.

Average Difference Test

Continued with the average difference test, based on the calculation results $t_{count}=3.56>1.67=t_{table}$, then H0 is rejected, meaning that the average Visual Spatial Ability ability of students who obtained the student visual spatial ability model in the 6E-IM model assisted by Geogebra is more than or equal to students in the 6E-IM model.

Proportion Difference Test

The proportion difference test was conducted to determine the difference in the number of students who achieved the completion of students' visual spatial ability in the 6E-IM model assisted by Geogebra, with the number of students who achieved the completion of students' visual spatial ability in the 6E-IM model. Because $Z_{count}=3.773>1.645=Z_{table}$, then H_0 is rejected, meaning that the proportion of students' visual spatial ability completion who obtained the model proportion of students' visual spatial ability completion in the 6E-IM model assisted by GeoGebra is more than or equal to students in the 6E-IM model.

Improvement Test

This hypothesis test was conducted to determine whether there was an increase in students' visual spatial ability before the 6E-IM model assisted by GeoGebra was applied with after the 6E-IM model assisted by GeoGebra was applied. The data used in this test were the values of the pre-test and post-test of visual spatial ability. Based on the SPSS output results above, it shows that the data has a *Sig.*<0.05, so H0 is rejected. This means that the average visual spatial ability of students who obtained the 6E-IM model assisted by GeoGebra is more than or equal to students before obtaining the 6E-IM model assisted by GeoGebra. After it was known that there was a difference between the pre-test and post-test, the researcher then used the gain formula. Based on the gain criteria obtained, namely 9.91%, it was in the interval of 70%-31 %, which means that the increase in the visual spatial abilities of students in the experimental group was classified as moderate.

Test of the Effect of the 6E-IM Learning Model Assisted by GeoGebra on Students' Visual Spatial Ability

This hypothesis test was conducted to determine the effect of the 6E-IM learning design assisted by GeoGebra on students' visual spatial ability. The data used in this test were the scores from the students' visual spatial ability questionnaire and the post-test. Based on the SPSS output results above, it can be concluded that *Sig.*=0.022<0.05=α, thus it can be said that the 6E-IM learning model assisted by GeoGebra has a positive and significant effect on students' visual spatial ability.

One of the learning models that is expected to be able to improve students' mathematical visual spatial intelligence is the 6E-IM learning design. Research conducted by Mardiyah et al. (2020) found that the 6E Instructional Model was able to significantly improve students' conceptual understanding, because this model places students as the center of the learning process and teaches them to be actively involved in exploring new concepts. Thus, the integration of 6E-IM in mathematics learning, especially with the support of technology such as GeoGebra, provides great potential to improve visual spatial intelligence, as supported by various studies that have been conducted in various learning contexts.

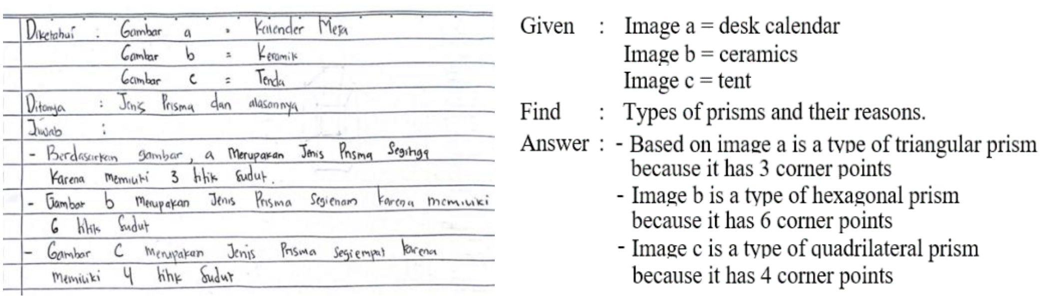
The results of the questionnaire on students' visual spatial ability categorized as high were 8 people (26.6%), medium 11 people (36.6%), and low 11 people (36.6%). The next step, 6 students were taken as research samples based on the results of the student visual spatial ability questionnaire. The six students were selected in each category of student visual spatial ability test results, namely 2 students with high visual spatial ability taken from the highest score in the high category, 2 students with medium visual spatial ability taken from the middle score in the medium category, and 2 students with low visual spatial ability taken from the lowest score.

Table 5. Results of determination of research subjects

No	Code	Visual spatial ability		Visual Spatial Ability Test Result
		Skor	Category	
1	E-5	83	High	90
2	E-6	115	Medium	78
5	E-2	59	Low	73
6	E-21	57	Low	69

High visual spatial ability research subjects E-05

Figure 3 show the fulfillment of the visual spatial ability indicator, namely being able to recognize the shape of a prism space shape visually and being able to imagine and draw a representation of a prism in various positions.


Diketahui : Gambar a = Kalender Meja
Gambar b = Keramik
Gambar c = Tenda
Ditanya : Jenis Prisma dan alasannya
Jawab :
- Berdasarkan gambar, a Merupakan Jenis Prisma Segitiga Karena memiliki 3 titik sudut.
- Gambar b Merupakan Jenis Prisma Segienam karena memiliki 6 titik sudut
- Gambar C merupakan Jenis Prisma Segiempat karena memiliki 4 titik Sudut

Given : Image a = desk calendar
Image b = ceramics
Image c = tent
Find : Types of prisms and their reasons.
Answer : - Based on image a is a type of triangular prism because it has 3 corner points
- Image b is a type of hexagonal prism because it has 6 corner points
- Image c is a type of quadrilateral prism because it has 4 corner points

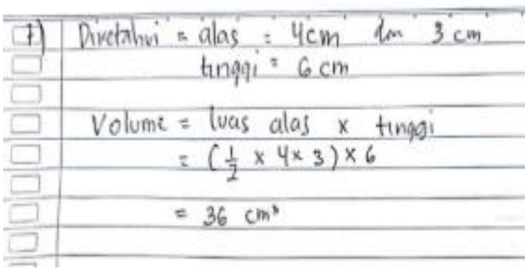
Figure 3. Subject E-05 answer to number 1

Subject E-05 can answer interview questions related to question number 1 well and there is no visible error pattern, this strengthens the test results that subject E-

05 is able to fulfill the visual spatial ability indicator, being able to recognize the shape of a prism space shape visually and being able to imagine and draw a representation of a prism in various positions.

Medium visual spatial ability research subjects E-06

Based on Figure 4, on the results of student work and be comparing it with the answer key, that can be seen in the attachment. In the student's work, the student was less careful in writing the question number which should have been 8 but was written as 7, was able to write the data known in the question, this is in line with the indicator of being able to imagine and draw representations of prisms in various positions, but there are answers that have not been written, namely being asked.



Given : Base = 4cm and 3 cm

Height = 6cm

Volume = base area x height

$=(\frac{1}{2} \times 4 \times 3)$

$= 36\ cm^2$

Figure 4. Subject E-06's answer to number 7

After the stage of being able to imagine and draw representations of prisms in various positions, the student takes the next step, namely being able to solve questions related to volume, surface area, and properties of prisms. In the student's work above, determining the completion plan can be seen by students determining the steps to complete when doing their work. The results were worked on by students by writing the prism volume formula and working on it with the correct answers.

Low visual spatial ability research subjects E-21

Figure 5, it can be seen that students are able to apply the indicator of being able to manipulate prism elements in 2D or 3D form, but students are wrong in describing the type of prism asked in the question.

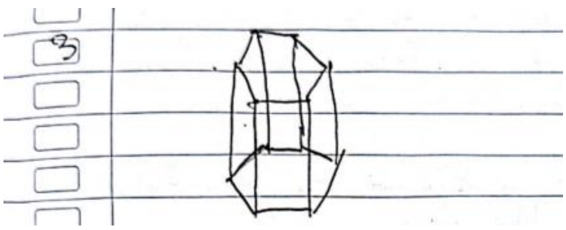


Figure 5. Subject E-21's answer to number 3

DISCUSSION

Based on the validation results of the learning devices and research instruments that have been prepared, the average assessment from the validator gave a very good category assessment for the learning device of the teaching module, student worksheet, pre-test, and post-test, observation sheets, visual spatial ability questionnaires and interview guidelines have validity with a very good category.

At the implementation stage of the 6E-IM statistical learning model assisted by Geogebra, based on the results of observations by observers from the first meeting to the sixth meeting, learning was carried out well and was in accordance with the learning design in the teaching module.

Research compiled by Sudirman (2022) that the results of the study showed that there was a significant influence of geometry self-efficacy and learning (6E-IM Integrated AR and 6EIM) on students' 3D geometry thinking skills. The magnitude of the influence is 20.5% and 16.2%, respectively. Malau et al. (2017) showed that students taught using the inquiry learning model with GeoGebra demonstrated greater improvements in spatial ability and self-confidence than those taught without GeoGebra.

These results were achieved because learning with the 6E-IM model assisted by GeoGebra allows students to understand and solve problems according to context. Furthermore, the 6E-IM model requires students to be able to understand their problems, and the teacher only acts as a facilitator to support students' problem-solving process and develop problem-solving skills based on the 6E-IM model problems through student worksheet.

These results are also supported by the results of the Hypothesis III Test, which show that the average visual spatial ability of students with the 6E-IM model assisted by GeoGebra is higher than the average ability of the 6E-IM model Spatial Visual Ability. Therefore, it can be concluded that the quality of the experimental group's visual spatial skills is higher than the control group.

Based on the results of the test of the influence of learning the 6E-IM model assisted by GeoGebra on students' visual spatial abilities, the SPSS output results above can be concluded that that 6E-IM learning assisted by GeoGebra has a significant effect on students' visual spatial abilities. In line with the research compiled by Sudirman (2022) that the results of the study showed that there was a significant influence of geometry self-efficacy and learning (6E-IM Integrated AR and 6E-IM) on students' 3D geometry thinking skills.

Thus, it can be concluded that this study is in line with previous studies. The better the students' spatial visual abilities, the better the students' spatial visual abilities in learning using the Geogebra-Assisted 6E-IM method.

CONCLUSION

Based on the results Based on the results of the study related to the Design of the 6E Learning Model Assisted by Geogebra Media in Improving Students' Mathematical Visual Spatial Ability in Prism Material, the following conclusions were obtained. (1) The geometry learning module with the 6E-IM learning model assisted by Geogebra is in the very good category. (2) The 6E-IM learning model assisted by Geogebra has a positive effect on students' visual spatial abilities. (3) Students who have high visual spatial abilities can understand the problem well, students with moderate visual spatial abilities are at the stage of understanding the problem, the party being reflected has a good understanding of the problem, students with low visual spatial abilities tend to have difficulty in identifying the questions contained in the problem. Students are able to identify the information needed, but it is not yet complete.

ACKNOWLEDGMENT

The authors acknowledge all participants involved in this study, expressing gratitude for their contributions that were integral to its completion.

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