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Analysis of Mathematical Representation Capabilities in Geometry Materials Assisted by Geogebra Applications

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ABSTRACT

This study aims to determine the ability of mathematical representation of students in geometry material after learning with the help of GeoGebra. This research is motivated by students' difficulty in interpreting geometric shapes. This research is qualitative research with a descriptive approach. The subjects in this study were 3 (three) class XII students who had obtained three-dimensional material with the help of GeoGebra applications. Researchers carry out the data collection process by providing mathematical representation ability test questions, conducting interviews, and taking documentation. The data obtained in this study were analyzed using specialized triangulation-checking techniques. Based on the results of data analysis and the effects of interviews with all research subjects, it can be concluded that learning geometry with the help of GeoGebra applications can improve mathematical representation capabilities. Three mathematical representation abilities, namely visual representation, equation or expression, and written words or texts, are possessed by students after learning geometry with the help of GeoGebra applications.

Keywords: Mathematical Representation, Geogebra, Geometry

ABSTRAK

Penelitian ini bertujuan untuk mengetahui kemampuan representasi matematis siswa pada materi geometri setelah belajar dengan berbantuan geogebra. Penelitian ini dilatarbelakangi oleh kesulitan siswa dalam melakukan interpretasi pada bangun ruang. Penelitian ini merupakan penelitian kualitatif dengan pendekatan deskriptif. Subjek dalam penelitian ini adalah 3 (tiga) orang siswa kelas XII yang telah memperoleh materi dimensi tiga dengan berbantuan aplikasi geogebra. Peneliti melakukan proses pengumpulan data dengan memberikan soal tes kemampuan representasi matematis, kemudian melakukan wawancara, serta mengambil dokumentasi. Data yang diperoleh dalam penelitian ini dianalisis dengan teknik pengecekan menggunakan triangulasi teknik. Berdasarkan hasil analisis data dan hasil wawancara dengan semua subyek penelitian dapat disimpulkan bahwa pembelajaran geometri dengan berbantuan aplikasi geogebra dapat meningkatkan kemampuan representasi matematis. Tiga kemampuan representasi matematis yaitu representasi visual, persamaan atau ekspresi, dan kata-kata atau teks tertulis dimiliki oleh siswa setelah belajar geometri dengan berbantuan aplikasi geogebra.

Kata Kunci: Representasi Matematis, Geogebra, Geometri

INTRODUCTION

One subject matter that is often difficult for some students is the subject matter of three-dimensional space. Some students have difficulty constructing the area into a flat plane. Seen the image made by the student that should be a right triangle, the student draws an isosceles triangle because the image on the cube looks like an isosceles triangle. This can be seen in Figure 1.

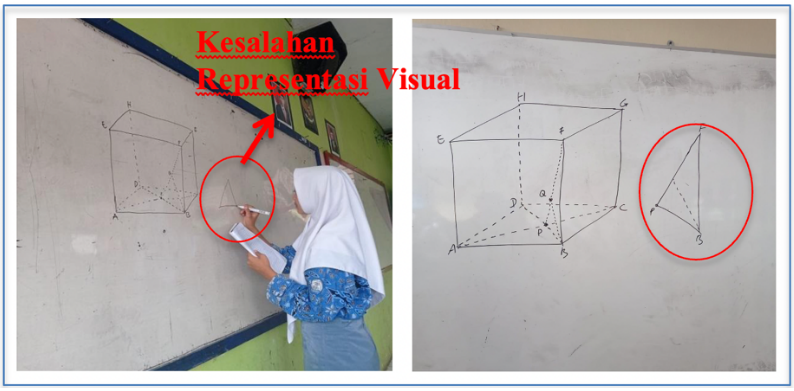

Figure 1. The difficulty of construction students build space

The problem in figure 1 also occurs elsewhere. The study results (Hajar et al., 2021) stated that most students find three-dimensional material challenging to understand. One of the difficulties lies in drawing space from a story that is not yet known to the picture. Most three-dimensional questions are description questions that require reasoning to solve them.

Based on observations made by researchers on class XII social studies three students, the fact was obtained that student learning outcomes on three-dimensional material were still relatively low. This can be seen in Table 1.

Table 1. Math Test Recap Three-Dimensional Space Subject Matter.

Value	Frequency
20	1
30	6
40	12
50	6
60	7
70	2
80	1
Summary	35

Based on the data in table 1, it can be seen that there are still many students who get a score below 60. This shows that students still have difficulty solving the three-dimensional space problem. This is in line with research (Mahdayani, 2016), which stated that 70.1% of students from the subjects studied had difficulty solving geometry problems. In addition (Basuki, 2012) has researched students' challenges in geometry material caused by the low ability to think abstractly. From the analysis of students' answers that obtained low scores, most students have not been able to construct a space into a flat plane, which can be seen in Figure 2.

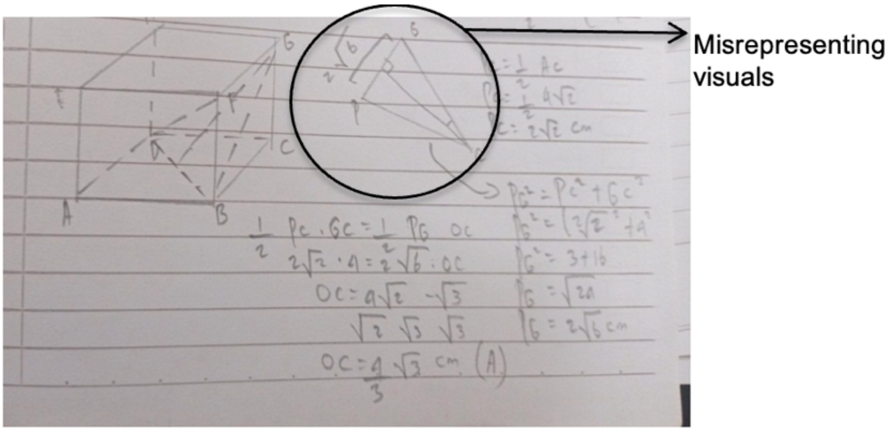

Figure 2. Students' answers to three-dimensional questions

From the picture above, it can be seen that students have not been able to draw a flat plane constructed from the building space on the question because the image made is not correct. The formula used is not right, so students give incorrect answers. Students have not been able to reason well when abstract understanding objects. New students can understand the condition when assisted with a solid or more concrete thing. In solving the problem, students have not been able to use thinking with awareness, and students have not realized a step in solving the problem. Students only solve the problem by trial and error or as long as they answer

Based on the facts mentioned above, the problem in this study is that students still have difficulty solving the three-dimensional space problem because students have not been able to construct the space into a flat plane. One of the abilities that students must have to solve geometry problems is the ability to represent mathematically. In solving mathematical problems before providing solutions, it must be started with the representation of the problem first. If students struggle to define the problem, it is likely difficult to solve or mistakenly provide it (Amaliyah AR & Mahmud, 2018). The ability of mathematical representation can be seen in how students solve problems and solve problems according to Polya through the stages of understanding the problem, choosing how to solve it, determining the solution, and re-examining the results of the solution (Polya, 2004).

Geometry has a greater chance of being understood by students than other mathematics branches. This is because students knew geometry ideas before entering school, such as lines, planes, and spaces. Nevertheless, evidence in the field shows that geometry learning outcomes are still low (Abdussakir, 2009).

Van Hiele's theory, developed by two Dutch educators, Pierre Marie van Hiele and Dina van Hiele-Geldof, explains the development of student thinking in learning geometry (Fitriyani et al., 2018). According to van Hiele's theory, a person will go through five stages of development of thinking in learning geometry (Crowley, 1987). The five stages of van Hiele's thinking development are stage 0 (visualization), stage 1 (analysis), stage 2 (informal deduction), stage 3 (deduction), and stage 4 (rigor).

Van Hiele's thinking stages will be passed by students sequentially (Crowley, 1987). Thus, students must go through a step maturely before heading to the next scene. This is in line with the facts found, and students have not been able to solve the three-dimensional problem without constructing the space into a flat plane. The speed of moving from one stage to the next depends more on the content and method of learning than age and maturity (Crowley, 1987; Keyes & Levy, 1997; Schoen & Hallas, 1993). Thus, the teacher must provide a learning experience that matches the student's thinking stage.

According to the theory of cognitive development by Jean Piaget, at the age of 12 years and above, a new period of operation arises. During this period, the child can use his concrete functions to form more complex processes (Jarvis, 2005). The progress in the child during this period is that he does not need to think with the help of concrete objects or events. He can think abstractly. Children are already able to understand the form of the argument and are not confused by the side of the idea; therefore, it is called formal operational. Piaget believes that we all go through all four stages, although perhaps each step is passed at a different age. Each set is entered when our brain is mature enough to allow new logic.

At the concrete operational stage, the child is mature enough to use logical thinking or operations, but only for today's physical objects. In this stage, the child has lost a tendency to animism and artificialism. His egocentrics are diminishing, and his conservation task ability is improving. However, without physical objects in their presence, children at the concrete operational stage still have great difficulties in solving logical tasks. In formal operations, children can use essential functions to form more complex processes. The progress in the child during this period is that he does not need to think with the help of concrete objects or events. He can think abstractly. Children can already understand the form of the argument and are not confused by the side of the idea; therefore, it is called formal operational. The age of high school students based on Piaget's theory of cognitive development is at a properly active stage, so high school students can already reason without the help of concrete objects. But, based on the results of simple observations during the learning process of Dimension Three, students tend to have difficulty in imagining, drawing, or illustrating a three-dimensional building, so often teachers have to bring a space-building model or concrete three-dimensional props to help students with understanding the concept of three-dimensional geometry that they want to explain (Novita et al., 2018)

Students in the 12th grade of high school should ideally be at the formal operational stage because they are over 12 years old. However, some students still have difficulty reasoning without the help of concrete objects, so students need the help of more important things to maintain well. This is in line with the opinion of (Widodo & Wahyudin, 2018), who argues that high school students are not yet entirely at the stage of formal thinking. Hence, teachers need to bridge it by using semi-concrete media. As in the three-dimensional space material, there are still students who cannot reason to interpret the actual object; students only understand the object as it seems, so they cannot reconstruct it according to the real thing.

According to Swartz & Chang (1998), a student's problem-solving ability consists of four levels. First, implicit use is the use of mindlessness. At this level, the type of thinking involves making decisions without thinking about those decisions. At this level, students apply strategies or skills in solving problems through trial and error or the origin of answering. Second, aware use is the use of thought with awareness. At this level, the type of thinking relates to the student's understanding of what and why the student is doing the study. At this level, students have realized a problem-solving step by explaining the use of the action. Third, strategic use is the use of strategic thinking patterns. At this level, the type of thinking used is related to the regulation of the individual in his thought process consciously by using specific strategies that can improve the accuracy of his thinking. At this level, students are aware and able to select particular strategies or skills to solve problems. Fourth, reflective use is the use of reflective thinking. At this level, the type of thinking used has to do with the reflection of the individual in his thought processes before and after or even during the process taking into account the continuation and improvement of the results of his thinking. At this level, students are aware of and correct mistakes made in the problem-solving steps.

Based on the analysis of students' answers in solving three-dimensional space questions, students have not been able to use thinking with awareness; students have not realized a step in solving the problem. Students only solve the problem by trial and error or as long as they answer. To assist students in solving these problems, especially in three-dimensional space materials, teachers must be able to make learning steps that can improve students' ability to construct space into a flat plane so that students can understand the steps for solving problems.

One of the efforts that teachers can make in learning so that students can solve three-dimensional problems is using the help of technology. Technology, especially computers, is a medium for connecting abstract mathematical ideas with concrete mathematical ideas. The role of educators or teachers is to improve the quality of education by designing classroom learning so that students get meaningful learning. A da various types of applications that can be used in mathematics learning, one of the applications that can be used is the Geogebra application. We are not teaching to memorize but to understand the material. In addition, learning geometry with the help of Geogebra does not depend on students' initial abilities, meaning that students' abilities can increase from previous capabilities (Supriadi, 2015). In line with the above opinion, with the existence of Geogebra learning media, students will quickly understand the learning material because students' attention is more directed to the learning process by involving their senses more.

The purpose of this study is to see the ability of students' mathematical representation of three-dimensional space materials after learning with the help of GeoGebra applications. The use of Geogebra in learning to improve students' understanding of mathematical concepts has been researched by The results of the study are in line with (Jelatu et al., 2018) namely the use of GeoGebra in learning can provide an excellent understanding of geometry concepts. Furthermore, (Nuritha & Tsurayya, 2021) developed media using GeoGebra and obtained the results of using GeoGebra-assisted learning videos declared effective for use as media and increasing student learning independence. Therefore, using Geogebra in learning is expected to improve mathematical representation skills so students can construct space into a flat plane.

METHODS

This research is qualitative with a descriptive approach because researchers try to obtain descriptive data in the form of students' written answers to questions. The subjects in this study were 3 (three) class XII students taken from high, medium, and low academic representatives who had obtained three-dimensional material with the help of GeoGebra applications. Researchers named S1 for the first participant, S2 for the second participant, and S3 for the third participant. Researchers carry out the data collection process by providing mathematical representation ability test questions, conducting interviews, and taking documentation. The data obtained in this study were analyzed by checking techniques using triangulation techniques.

The instruments used in this study were mathematical representation ability tests and interview guidelines. Mathematical representation ability test questions and interview guidelines are prepared based on indicators adapted from (Hand et al., 2009; Sari et al., 2020; Waluya & Asikin, 2021), namely (1) Visual Representation (in the form of a diagram, graph, table, or image); (2) Mathematical equations or expressions; and (3) Written words or text. The indicators of each mathematical ability are shown in Table 2.

Table 2. Mathematical Representation Ability Indicators and Interview Guidelines

No	Mathematical Representation	Indicators	Interview Guidelines
1	Visual Representation	• Drawing geometric patterns • Creating images to clarify the problem and facilitate its resolution	• What is understood from the situation? • What did you draw? • Why is the picture like that? • Which point is asked about the question? • Why was that point chosen?
2	Equation or Expression	• Create a mathematical equation or model from a given problem • Solving problems from already created mathematical models	• What formula or equation do you use? • Why choose that equation? • Where is the figure obtained from?
3	Written words or text	• Create a problem situation based on the data or representation provided • Write down the interpretation of a representation • Describes the steps of solving mathematical problems in words according to the presented representation	• To answer this question, explain the steps. What will be done first?

The questions tested are based on knowing the student's mathematical representation ability in solving geometry problems based on Polya steps and on unearthing information on students' thought processes that are not contained in the answer sheet. The instrument test used is presented in Table 3.

Table 3. Test Instruments

No	Question
1	A room has a length of 4m, a width of 4m, and a height of 4m. A lamp is located right at the center of the ceiling plane in the room's ceiling. A switch is installed on one of the room's walls, which is located right in the middle of the wall. What is the shortest distance between the button and the lamp in the space?

RESULTS AND DISCUSSION

The study results provided information from the beginning of giving questions to get participants as research subjects; from 30 research students gave queries, student answers were grouped from the high and medium low academic categories, and three students became our participants. The results showed that the average student enjoyed using the GeoGebra application. Representational thinking activities appeared as seen from the effects of observations of students' answers, followed by the truth from the results of in-depth interviews. The results of each participant's research will be explained one by one.

First Subject Research Results (S1)

The answers to the test questions given to the first-subject students can be seen in Figure 3.

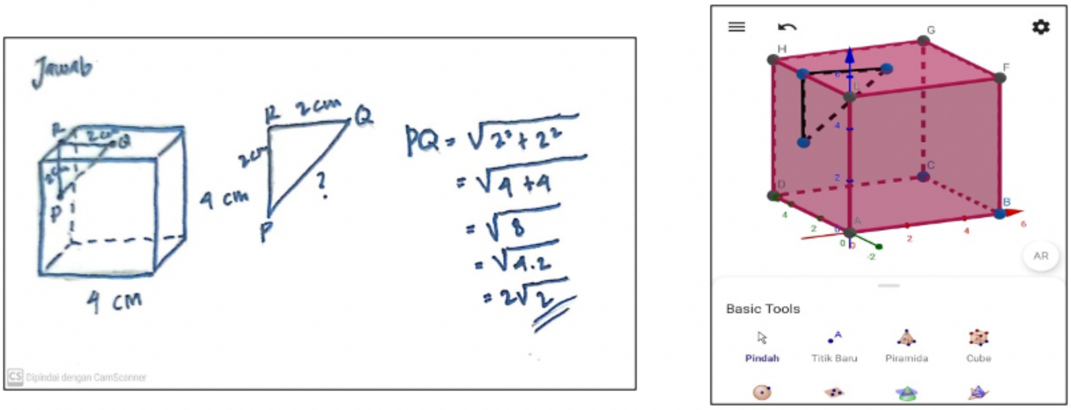

Figure 3. Answers to the first subject test questions

Based on figure 3, it can be seen that the first subject draws a cube equipped with points P, Q, and R. The first subject explains that the cube represents the chamber, and those points are the weak points and switches in the section. To calculate the distance of the control to the lamp, the first subject constructs a right triangle taken from the cube. The length of the switch to the light is represented by the distance of point P to point Q or the hypotenuse of the triangle PQR. The first text does not write down the formula for calculating the length of point P to end Q but directly uses numbers and obtains the result of the distance of the point P to point Q is $2\sqrt{2}$.

The results of the interview to validate the answers and find out the steps that the first subject worked on were as follows:

Q : *"From that problem, what do you imagine if it is associated with building space."*
S1 : *"my room is like a cube, then the room light is likened to the dots I connect that become a triangle."*
Q : *"why did the point you chose that one?"*
S1 : *"because looking for the nearest one."*
Q : *"to determine the answer, what formula do you use?"*
S1 : *"using Pythagoras, find the hypotenuse."*
Q : *"other than imaginatively, what app do you use to help solve this problem?"*
S1 : *"Geogebra, this application helped me. I became more imagined by looking at the images in this Geogebra application. I became happier to do it."*

The interview results showed that S1 thought visually restitutive by making a cube as a parable of the room. S1 expressed his expression using the Pythagoras formula. This was also conveyed during an in-depth interview. S1 has also said the wording of what he said when asked about what he did when solving the problem. S1 utilizes GeoGebra applications to help imagine building space, hoping it will make it easier to solve space-building issues. This aligns with research from (Gunčaga, 2011), which reveals the application of GeoGebra to teach teachers and motivate students to learn mathematics.

Results of the Second Subject Research (S2)

The answers to the test questions given to the second-subject students can be seen in Figure 4.

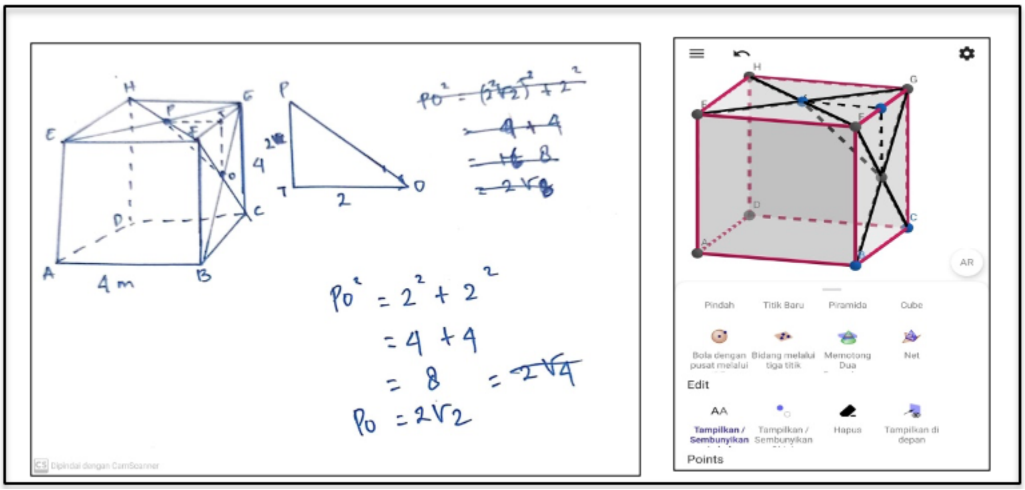

Figure 4. Answers to the second subject test questions

Based on figure 4, it can be seen that the second subject drew an ABCD cube. EFGH is equipped with P, T, and O points. The second subject explains that the cube represents the room, the light point is the diagonal cut point FH and EG, and the diagonal cut point switch BG and CF. The second subject chooses the oblique cut point because the light point and switch are in the middle of the ceiling and the middle of the wall. To calculate the distance of the control to the lamp, the third subject constructs a right triangle taken from the cube. The length of the switch to the light is represented by the distance of point P to point O or the hypotenuse of the PTO triangle. The second subject did not write down the formula for calculating the length of point P to point O but directly used the number and obtained the result that the distance of point P to O is $2\sqrt{2}$.

The results of the interview to validate the answers and find out the steps that the second subject worked on were as follows:

P : "I see your answer to build a cube. What do you imagine when you finish the question?"
S2 : "I imagine a room is a cube, so I describe building a cube because all sides are the same."
P : "Try to explain how you solved the problem from the beginning to get an answer. "
S2 : "I make a cube, then I make a point, this makes a line first, and then the intersection is made a point named point P, then in this field also the BCGF plane is the same created line first continues the middle point O."
P : "Why does the BCGF field choose the field? "
S2 : "Actually, whether you want it in the left, front, or backfield is also okay because the distance is the same so that the closest distance can be from all the walls, but I prefer the one that is pressed because the picture is clearer."
P : "then, to answer it, you use what formula? I see your answer directly. The number is written."
S2 : "it uses the Pythagoras formula, which is looking for the hypotenuse, so I immediately add it. The length of the upright sides is 2."
P : "to convince you that triangle is correct, how? "
S2 : "I use a GeoGebra. It's more accurate. I can rotate it so that it can be seen from another point of view if the triangle is right. If there is something that I can't imagine, I usually use GeoGebra assistance."

The interview results showed that S 2 thought visually representatively by making the parable of the room a cube. At the time of the in-depth interview, S 2 expressed his expression using the Pythagoras formula, S 2 was also presented with words he revealed when asked about what he did when solving the problem. S2 uses GeoGebra applications to ensure the construction of the created built space is correct. This aligns with research from (Aminah et al., 2022), in which the GeoGebra application can help review answers obtained manually.

Third Subject Research Results (S3)

The answers to the test questions given to the third-subject students can be seen in Figure 5.

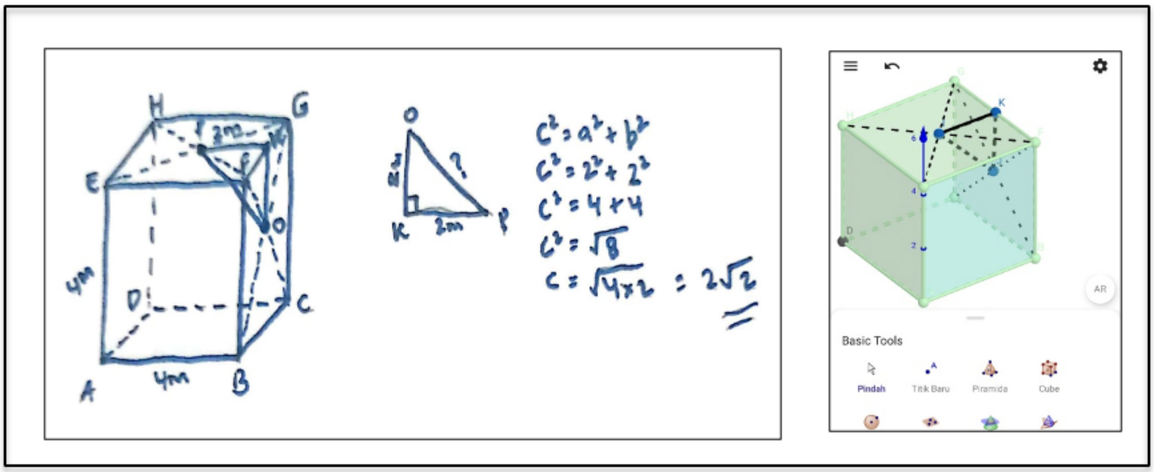

Figure 5. Answers to the third subject test questions

Based on figure 5, the third subject is seen drawing an ABCD cube. EFGH is equipped with points P, K, and O. The third subject explains that the cube represents the chamber, and the light point is FH and EG's diagonal cut points. For the diagonal cut-point switch BG and CF, the third subject choose the oblique cut point because the light point and switch are in the middle of the ceiling and the middle of the wall. To calculate the distance of the button to the lamp, the third subject constructs a right triangle taken from the cube. The length of the switch to the light is represented by the distance from point P to point O or the hypotenuse of the PKO triangle. The third subject wrote down the formula for calculating the length of point P to O, then subtracted the number on the triangle PKO and obtained the result of the distance of point P to point O being $2\sqrt{2}$.

The results of the interview to validate the answers and find out the steps that the third subject worked on were as follows:

P : "From your answer, I saw a picture of a space and a flat plane. Let you explain the meaning of the picture."

S3 : "the question asks the distance between the lights on the ceiling and the switch in the wall. Because the length, width, and height of the room are the same, I describe a cube".

P : "try to explain how you got that answer."

S3 : "from that cube, I created a midpoint in the upper plane as the light, then the center point of the right plane as the switch. I connect the lamp point and the switch into a triangle."

P : "then, to calculate the distance using what?"

S3 : "I use the Pythagoras formula because the triangle is right, the distance of the switch and the lamp as the hypotenuse because the lamp and switch are in the middle, so the length is the same."

P : "where did you know it was a right triangle? Just imagine it or how?"

S3 : "I use a GeoGebra, too, so that the image can be seen, so it's easy to imagine that it's a right triangle."

The interview results showed that S3 has a visual reflective ability by making cubes as a parable of the room. During a more in-depth interview, S3 expressed his expression by offering the Pythagoras formula. S3 has also explained in words what he did when solving the problem. S3 uses GeoGebra applications to make creating constructed triangles from built-up spaces easier. This is in line with research from in line with (Jelatu et al., 2018), namely, the use of GeoGebra in learning can provide an excellent understanding of geometry concepts.

Based on the results of the answers of all subjects and the results of the interview, it can be seen that all issues have the ability to represent mathematically, it is evidenced by the power of students to understand the given questions, then determine how to solve them, and complete until they get answers. From the visual representation indicators, it can be seen that students have been able to draw space as a representation of the room, then dots as a representation of lights and switches, and the subject can also explain the reason for each drawing made. Indicators of the equation or expression appear from the third subject, who writes down the equation and performs the substitution, for the first and second subjects directly use the numbers to calculate the requested distance. Still, all topics can determine the solution to the problem. For indicators of written words or texts, all subjects can provide a flat field interpretation obtained from building space to solve problems. The issues are also able to explain the steps for solving the problem.

From the results of interviews with the subjects, it is also known that the issues have been learned geometry with the help of GeoGebra applications. According to the subject, the advantages of GeoGebra applications are that they can help interpret complex images by rotating them so that they can be seen from different points of view so that the actual image can be supposed. This is in line with the results of research (Budiman & Rosmiati, 2020) which suggests that learning geometry with the help of Geogebra can improve students' mathematical reasoning abilities. In addition to being able to enhance the ability of representation and reasoning to apply Geogebra to learning, it can also increase student independence in learning (Lestari & Raya, 2022)

CONCLUSION

Based on the data analysis results and interviews with all research subjects, it can be concluded that learning geometry with the help of GeoGebra applications can improve mathematical representation capabilities. The three mathematical representation capabilities of visual representation, equation or expression, and written words or text can be seen from the answer sheet and the results of interview with subjects so that the teacher can use the GeoGebra application in learning geometry as a tool to improve students'' representation abilities.

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REFERENCES

Abdussakir, A. (2009). Pembelajaran Geometri Sesuai Teori Van Hiele. *Madrasah Jurnal Pendidikan Dan Pembelajaran Dasar*, *II*(1). https://doi.org/10.18860/jt.v2i1.1832.

Amaliyah AR, R., & Mahmud, N. (2018). Analisis Kemampuan Representasi Matematis dalam Pemecahan Masalah Geometri serta Faktor-Faktor yang Mempengaruhinya. *Jurnal Review Pembelajaran Matematika*, *3*(2), 146–160. https://doi.org/10.15642/jrpm.2018.3.2.146-160

Aminah, N., Sukestiyamo, Y., Wardono, & Cahyono, A. N. (2022). A Teaching Practice Design Based on a Computational Thinking Approach for Prospective Math Teachers Using Ed-Tech Apps. *International Journal of Interactive Mobile Technologies*, *16*(14), 43–62. https://doi.org/10.3991/ijim.v16i14.30463

Basuki, N. R. (2012). Analisis Kesulitan Siswa SMK pada Materi Pokok Geometri dan Alternatif Pemecahannya. *Seminar Nasional Pendidikan Matematika Surakarta 2012*, *21*(2), 97–104.

Budiman, H., & Rosmiati, M. (2020). Penerapan Teori Belajar Van Hiele Berbantuan Geogebra untuk Meningkatkan Kemampuan Penalaran Matematis Siswa. *Prisma*, *9*(1), 47. https://doi.org/10.35194/jp.v9i1.845

Crowley, M. (1987). The van Hiele model of the development of geometric thought. *Learning and Teaching Geometry, K-12*, 1–16. http://www.csmate.colostate.edu/docs/math/mathactivities/june2007/The van Hiele Model of the Development of Geometric Thought.pdf

Fajriadi, D., Priyadi, R., & Rahayu, D. V. (2022). Pengembangan Media Pembelajaran Geogebra Book Materi Dimensi Tiga. *Teorema: Teori Dan Riset Matematika*, *7*(2), 453. https://doi.org/10.25157/teorema.v7i2.8813

Fitriyani, H., Widodo, S. A., & Hendroanto, A. (2018). Students'geometric Thinking Based On Van Hiele's Theory. *Infinity Journal*, *7*(1), 55-60. https://doi.org/10.22460/infinity.v7i1.p55-60

Gunčaga, J. (2011). GeoGebra in Mathematical educational Motivation. *Computer Science Series*, *IX*(June), 75–84.

Hajar, S. S., Sofyan, S., & Amalia, R. (2021). Analisis Kemampuan Penalaran Matematis Siswa Dalam Menyelesaikan Soal Open-Ended Ditinjau Dari Kecerdasan Emosional. *Jurnal Ilmiah*

Matematika Realistik, *2*(2), 32–36. https://doi.org/10.33365/ji-mr.v2i2.1413
Hand, B., Gunel, M., & Ulu, C. (2009). Sequencing embedded multimodal representations in a writing to learn approach to the teaching of electricity. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *46*(3), 225-247. https://doi.org/10.1002/tea.20282
Jarvis, M. (2005). *The psychology of effective learning and teaching*. Nelson Thornes.
Jelatu, S., Sariyasa, & Made Ardana, I. (2018). Effect of GeoGebra-aided REACT strategy on an understanding of geometry concepts. *International Journal of Instruction*, *11*(4), 325–336. https://doi.org/10.12973/iji.2018.11421a
Keyes, T. K., & Levy, M. S. (1997). Analysis of Levene's test under design imbalance. *Journal of Educational and Behavioral Statistics*, *22*(2), 227–236. https://doi.org/10.3102/10769986022002227
Lestari, I., & Raya, U. S. (2022). *Penerapan Pembelajaran Virtual Moodle Berbantuan*. *3*(3), 537–542. https://doi.org/10.46306/lb.v3i3.164
Mahdayani, R. (2016). Analisis Kesulitan Siswa Dalam Pemecahan Masalahmatematika Pada Materi Aritmetika, Aljabar,Statistika, Dan Geometri. *Jurnal Pendas Mahakam,* , *1*(1), 86–98. http://103.8.79.252/index.php/pendasmahakam/article/view/39
Mayberry, J. F., Smart, H. L., & Toghill, P. J. (1986). Familial association between coeliac disease and ulcerative colitis: preliminary communication. *Journal of the Royal Society of Medicine*, *79*(4), 204–205. Retrieved from https://journals.sagepub.com/doi/pdf/10.1177/014107688607900405
Novita, R., Prahmana, R. C. I., Fajri, N., & Putra, M. (2018). Penyebab kesulitan belajar geometri dimensi tiga. *Jurnal Riset Pendidikan Matematika*, *5*(1), 18–29. http://dx.doi.org/10.21831/jrpm.v5i1.16836
Nuritha, C., & Tsurayya, A. (2021). Pengembangan Video Pembelajaran Berbantuan Geogebra untuk Meningkatkan Kemandirian Belajar Siswa. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(1), 48–64. https://doi.org/10.31004/cendekia.v5i1.430
Polya, G. (2004). *How to solve it: A new aspect of mathematical method* (Issue 246). Princeton university press.
Purwanti, R. D., Pratiwi, D. D., & Rinaldi, A. (2016). Pengaruh pembelajaran berbatuan geogebra terhadap pemahaman konsep matematis ditinjau dari gaya kognitif. *Al-Jabar: Jurnal Pendidikan Matematika*, *7*(1), 115–122. https://doi.org/10.24042/ajpm.v7i1.9699
Reis, Z. A., & Ozdemir, S. (2010). Using Geogebra as an information technology tool: Parabola teaching. *Procedia-Social and Behavioral Sciences*, *9*, 565–572. https://doi.org/10.1016/j.sbspro.2010.12.198
Sari, H. J., Kusaeri, A., & Mauliddin. (2020). Analisis Kemampuan Representasi Matematis Siswa Dalam Memecahkan Masalah Geometri. *Jurnal Pendidikan Matematika Indonesia*, *5*(2), 57. https://dx.doi.org/10.26737/jpmi.v5i2.1813
Schoen, H. L., & Hallas, D. (1993). Improving the general mathematics experience. *Research Ideas for the Classroom: High School Mathematics*, 103–118.
Supriadi, N. (2015). Pembelajaran Geometri Berbasis Geogebra Sebagai Upaya Meningkatkan Kemampuan Komunikasi Matematis Siswa Madrasah Tsanawiyah (MTs). *Al-Jabar : Jurnal Pendidikan Matematika*, *6*(2), 99–110. https://doi.org/10.24042/ajpm.v6i2.20
Swartz, R., & Chang, A. (1998). Instructional Strategies for Thinking Classroom. *Singapura: National Institute of Education*.
Waluya, S. B., & Asikin, M. (2021, June). Analysis mathematical representation ability by self-efficacy of prospective mathematics teachers. In *Journal of Physics: Conference Series* (Vol. 1918, No. 4, p. 042118). IOP Publishing. https://doi.or/10.1088/1742-6596/1918/4/042118
Widodo, S. A., & Wahyudin. (2018). Selection of Learning Media Mathematics for Junior School Students. *Turkish Online Journal of Educational Technology - TOJET*, *17*(1), 154–160. https://eric.ed.gov/?id=EJ1165728