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Geogebra in Real-Life: Important Tips to Support Student Creative Thinking in Mathematics

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ABSTRACT

Creativity is an important personality trait to use in everyday life. This allows us to be flexible when facing real life situations. Mathematics education should be seen as an opportunity for creativity development, even though creativity is not traditionally associated with mathematics. One of the goals of education at every level is to encourage students to think creatively, think logically, and be able to solve problems. This study aimed to provide important tips to support the student creative thinking when studying mathematics. This study also described activities outside the classroom that could develop the student creativity related to geometry. The methods used were surveys, interviews, and classroom and outdoor observations. We used brainstorming in mathematics education. The results of the research during the survey were visible. Researchers collaborated with students aged 19 to 21 years. We asked them to search for “any geometry” and take pictures of interesting objects while they were doing the activity. Next, students created ideas for geometry assignments based on the photos they took. The large collection of photos collected represented the basis for creating mathematical problems without any specific steps related to geometric objects. These open problems could be solved by students. In conclusion, Geogebra could encourage the student creative thinking by providing the opportunity to experiment with their own ideas and find solutions to mathematical problems.

1. Introduction

Mathematical creative thinking abilities are the result of mathematical creativity, whereas creative activities are learning activities designed to encourage or bring out the creativity of students. The development of creative thinking skills is essential, because it is one of the skills desired by employers [1-3]. The development of creative thinking abilities must be enhanced in accordance with the era, including the current technological era [4,5].

The technology-based learning is essential to balance the demands of the time and to equip students with life skills for the twenty-first century. It requires critical, creative, logical, and systematic thinking [6-8]. Moreover, many students lack creative reasoning abilities [9,10]. For

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instance, students feel confused about grouping elements that are known in the problem, feel confused about the initial stages of working on the problem, have errors in performing mathematical operations, and the monotony of the teacher example questions.

The learning method utilized in schools is still conventional, such as teacher-centred learning [11]. Different from new strategies in teaching such as student-centred learning [12,13], conventional learning is necessary for teachers to be able to generate an effective and efficient learning with the appropriate strategy and selection of learning models [14-17]. Creating a conducive learning environment is a method for enhancing mathematical and creative thinking abilities. This learning environment is crucial [18,51-53].

The purpose of this study was to examine how students investigated and experimented to develop their creative thinking skills, such as by going to the library, malls, cinemas, cafes, picnics, staycations, camping, and so on. This research used survey methods, interviews, classroom and outdoor observations, and brainstorming. The results of this research showed that Geogebra could encourage students to think creatively by providing the opportunity to experiment with their own ideas and find solutions to mathematical problems. The novelty of this research is the discovery that the use of Geogebra, the integration of activities outside the classroom with Geogebra, and presentation of open problems can support the student creative thinking.

2. Methodology

This research strategy employed phenomenological and survey techniques. The phenomenology method is used to explore the subject's experiences in depth, while surveys are used to collect data from a broad number of respondents. The combination of these two techniques can provide a comprehensive understanding of the phenomenon under study. This phenomeno-logical method was utilised to comprehend and investigate the subjective experiences in developing mathematical creative thinking skills [9]. Meanwhile, the survey method was used to comprehend the opinions and behaviours of students involved in the development of mathematical creative thinking skills. It was also used to gain insight into these factors. The participants involved were selected by purposive sampling technique. This is due to the consideration that there is only one class that takes geometry courses using Geogebra.

This research uses oral and written data sources. There were open interview sheets and observation sheets used. The data were analysed using both descriptive and geometric visualisations. Researchers conduct observations by examining the physical environment and pupils learning both inside and outside of the classroom. Aside from that, researchers conduct observations by tracking and watching a sequence of activities or pupils learning processes. This observation seeks to determine how pupils use Geogebra in class and in real life outside of class, yet it remains tied to geometry. The survey was undertaken to determine the emerging potential of pupils and whether Geogebra can truly help students' thinking processes in mastering geometry material. Next, interviews with students were done to learn more openly and in depth about the creative thinking process in mastering geometry with Geogebra. The data was analysed using both descriptive and geometric visualisation.

3. Results

3.1 Mathematical Creative Thinking and Van Hiele Theory

Mathematical creative thinking skills are abilities that allow students to discover a variety of solutions or ideas to solve problems, not only mathematical problems but also the creativity required for work. This can help how the mathematics can be delivered by teacher to student [19-38]. Creative thinking skills are the abilities to generate numerous ideas that result in something new, to describe objects, and to solve problems using specific techniques [39]. Students are considered mathematically creative if they can solve routine math problems using different methods. Based on the definitions of creative thinking skills provided by experts, it concludes that mathematical creative thinking skills are the ability to solve mathematical problems quickly, effortlessly, and flexibly.

Mathematical and creative thinking skills are required to develop logical, analytical, systematic, critical, creative, and cooperative thinking abilities. Silver claims that open-ended queries can foster creative thinking. Creative thinking can be developed through challenging questions [40]. Students base their decisions on perception rather than logic. Students comprehend the implications of logic and class inclusion, for instance they recognise that a square is one type of rectangle [41]. The abilities enhance the student comprehension of symbols, shapes, tables, and images [42].

3.2 Geometry from the Student Point of View

We recruited students aged 19 to 21. Through their daily activities, students can develop their creative ideas [43-46]. In this activity, students were tasked with locating and photographing geometric objects. In addition, students were asked to construct ideas when completing geometric assignments in the previous activity. Students were able to obtain mathematical problems and predict solutions based on the documentation. It has been demonstrated that students can develop their mathematical creative thinking abilities through their own activities [17-19]. During the study, the students were given the following difficulties:

i. Based on your observations, draw or design the dome of the SKA Pekanbaru complex! Then, what do we conclude about the geometric shape
ii. If the diameter of a geometric shape is given, calculate the volume by designing the steps!
iii. Based on your observations, design or determine the geometric shapes of the pillars of the Pekanbaru regional library!
iv. Construct a mathematical model to determine the volume based on a given measurement. Then, devise the appropriate steps!

Students completed the tasks using conventional methods and Geogebra software with their own creative concepts. The solutions to these problems were presented in the form of student-created photos and designs generated by the Geogebra software.

3.2.1 Photos from students with math ideas

The primary objective of problem creation was to foster mathematical thinking, ideas, and problem-solving abilities among students. Following the primary objective of completing specific assignments, students could complete the shape measurement on the photo, as seen in Figure 1 and Figure 2.

The followings are the primary objectives:

i. Construct or generate geometric issues based on experience,
ii. Generate issues based on the observed object,
iii. Determine the observed object dimensions and adjust them accordingly,
iv. Observe comparable objects and measure their dimensions.

In the following section, students clarified the issue serving as the impetus for the activity concept. These problems inspired students to develop their own problem-solving skills and inventiveness.

Fig. 1. SKA Mall Pekanbaru Dome

Fig. 2. Pekanbaru Regional Library Support Pole

3.2.1.1 Problem solving a

Figure 3 is the SKA mall dome design without Geogebra software.

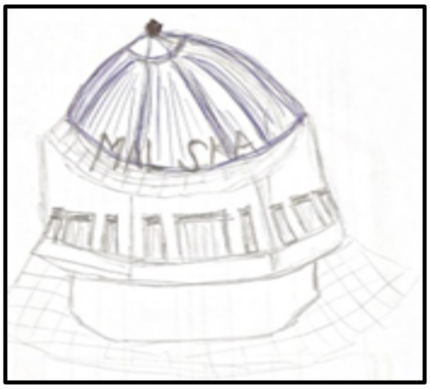

Fig. 3. SKA Mall Pekanbaru Dome

3.2.1.2 Problem solving b without the use of Geogebra

Known: I chose the diameter of 30 cm
Question: $V_{half\ ball}$?
Answer: Because $V_{ball} = \frac{4}{3}\pi r^3$, so $V_{half\ ball} = \frac{1}{2}(V_{ball})$
$V_{half\ ball} = \frac{1}{2}(V_{bola})$
$V_{half\ ball} = \frac{1}{2}\left(\frac{4}{3}\pi r^3\right)$
$V_{half\ ball} = \frac{2}{3}\pi r^3$
$V_{half\ ball} = \frac{2}{3} \cdot \frac{22}{7} \cdot 15^3$
$V_{half\ ball} = \frac{44}{21}(3375)$
$V_{half\ ball} = (2{,}095)(3375)$
$V_{half\ ball} = 7070{,}625\ cm^3$

3.2.1.3 Problem solving c

Figure 4 is a support pillar for the Pekanbaru Regional Library without using Geogebra software.

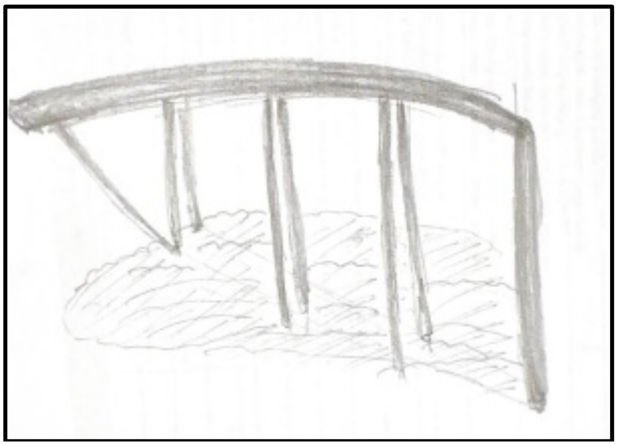

Fig. 4. Pekanbaru Regional Library Support Pole

3.2.1.4 Problem solving d without Geogebra

Known: I chose a beam with a height 15 cm, long 8 cm, and wide 7cm.
Question: V_{beam}?
Answer:
$V_{beam} = p \times l \times t$
$V_{beam} = 8 \times 7 \times 15$
$V_{beam} = 840cm^3$

3.2.2 Using Geogebra to resolve the issue

In this section, the researcher chose a problem for a custom-made assignment. Geogebra is the ideal tool for teaching mathematics in elementary schools, secondary schools, and universities, given that new developments in mathematics have led to the use of the software to enhance and enliven mathematics education. Using this software, researchers hoped to emphasize dynamic factors that could influence the results or number of solutions to a problem in the following ways:

3.2.2.1 Problem solving a

Figure 5 is a design of the SKA mall super structure created using Geogebra.

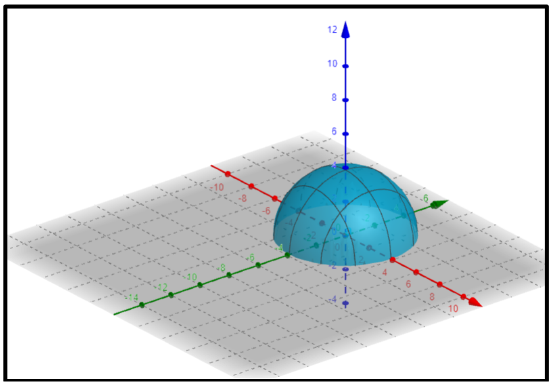

Fig. 5. SKA Dome Created Using Geogebra

From Figures 3 and 5, we can conclude the following about these images:

i. The front, side, and rear views are semicircular.
ii. Seen from above, it resembles a hemisphere.
iii. When observed from below, it appears to be a circle.
iv. One of the image contours reveals the shape to be a parabola.

3.2.2.2 Problem solving b with Geogebra

Known: I chose the diameter of 30 cm
Question: volume
Answer:
a. Open the Geogebra application as shown in the Figure 6.

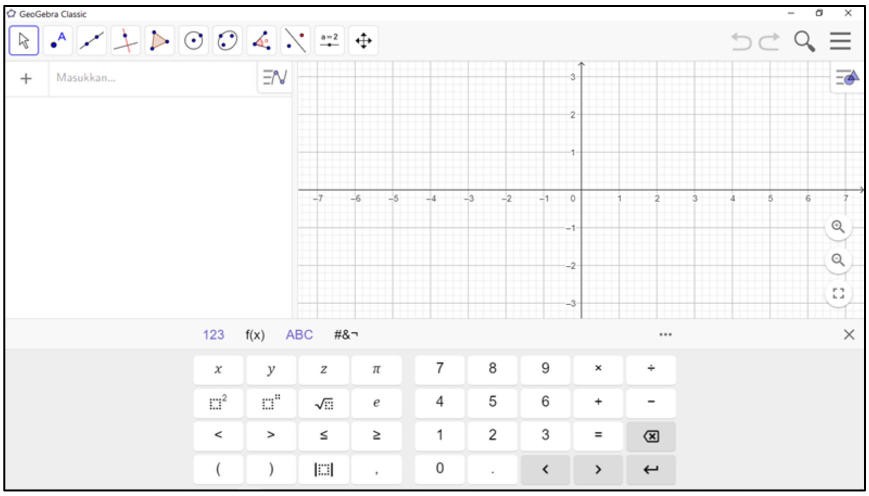

Fig. 6. Display after Opening Geogebra Software

b. To create a 3D perspective, select the tool  which is located in the upper right corner of the Geogebra window, then a display will appear as in Figure 7.

Fig. 7. Other Tools

c. Click the triple vertical dots and choose "View 3D Graphics" as shown in Figure 8. Then, the 3D graphic display will look like Figure 9.

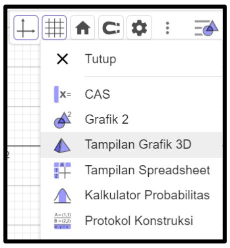

Fig. 8. Other Tools

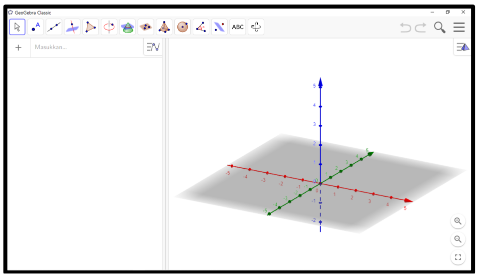

Fig. 9. The 3D Graphic Display

d. In addition, because it was initially determined that the diameter of the half ball was 30 cm, type $r = 15$ in "Enter..." to outline the half ball, as shown in Figure 10. Then, following input and a click of the enter key. The text will appear as shown Figure 11.

Fig. 10. Outline the Half Ball

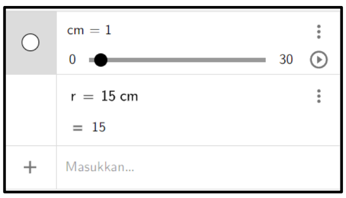

Fig. 11. Half Ball Final Result

e. Underneath, retype the formula for the equation of a circle with radius r, namely $\sqrt{r - x^2 - y^2}$ then press Enter. The result will resemble the Figure 5, as seen in Figure 12. Then, to calculate the volume of a semicircle, rewrite the formula for the volume of a half sphere, $\left(\frac{2}{3}\right)\pi r^3$ below it and press enter, as shown in Figure 13.

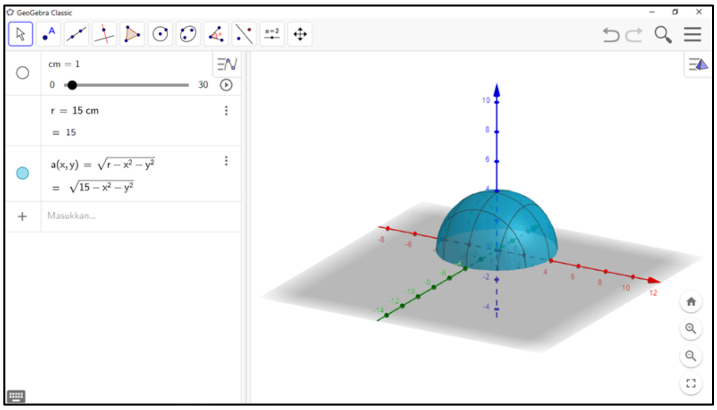

Fig. 12. The Result of the Formula for the Equation of a Circle

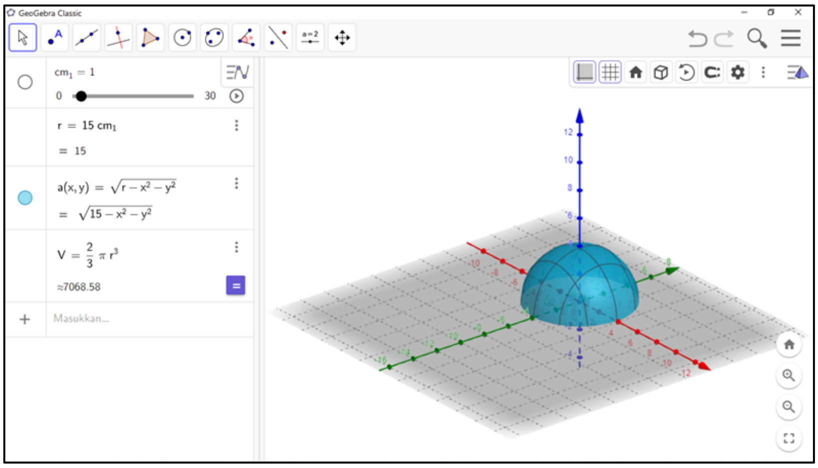

Fig. 13. The Resulting Volume of a Semicircle

f. To make the 3D view appear more organized, we can remove the background from the planes and coordinate lines by selecting a transparent white colour from the tool, as shown in the Figure 14. Then, it will look like the Figure 15.

Fig. 14. Tool for the 3D View

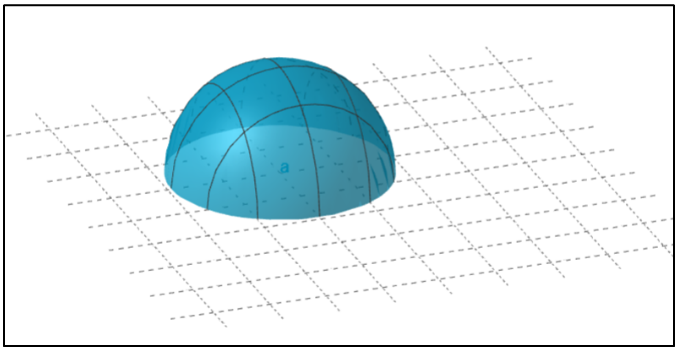

Fig. 15. Final Result

3.2.2.3 Problem solving c

Using Geogebra software, regional library support poles are drawn or designed.

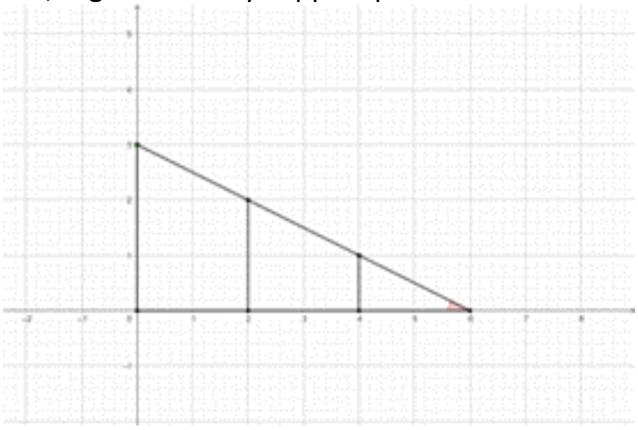

Fig. 16. Regional Library Support Poles with Geogebra

3.2.2.4 Problem solving d with Geogebra

Known: I chose a block that has 15 cm in height, 8 cm in length, and 7 cm in width.
Question: V_{beam}?
Answer:
a. Open the Geogebra application as shown in Figure 17.

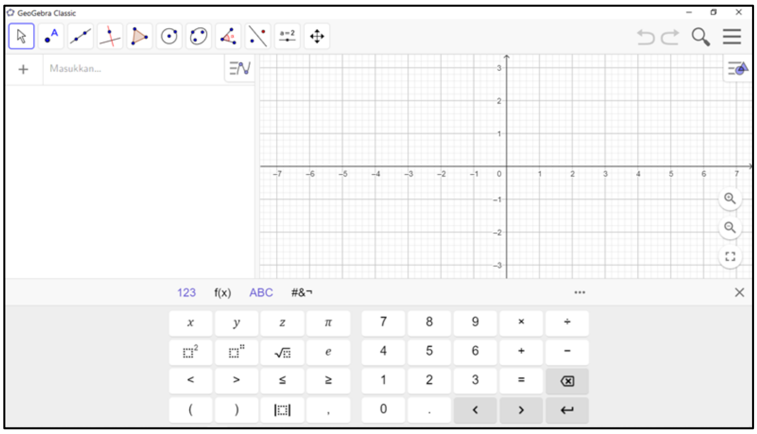

Fig. 17. Display after Opening Geogebra Software

b. To create a three-dimensional view, click the tool  in the upper right corner of the Geogebra window, and a display similar to the one below will appear in Figure 18.

Fig. 18. Other Tools

c. Click the three vertical dots and select "Graph View 3" as shown in Figure 19. Then, the 3D graphic display will resemble the Figure 20.

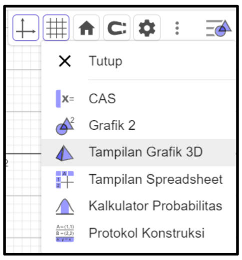

Fig. 19. Other Tools

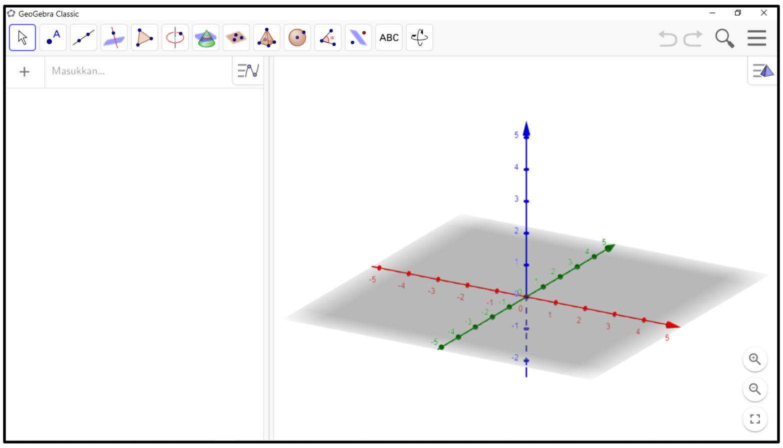

Fig. 20. The 3D Graphic Display

d. To create a beam, select the tool , select "Polygon" as depicted in the accompanying in Figure 21.

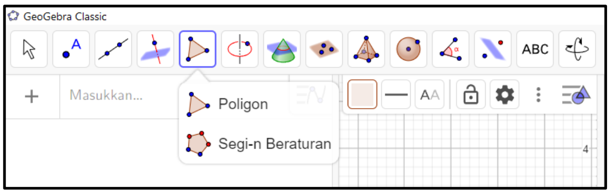

Fig. 21. Polygon Tool

e. Because it was initially determined p = 8 cm and l = 7 cm, form a beam by clicking (0, 0) and adjust its length and width to the specifications as shown in Figure 22. Then, as demonstrated in Figure 23, use the "Force to Prism or Cylinder" tool to create a block shape.

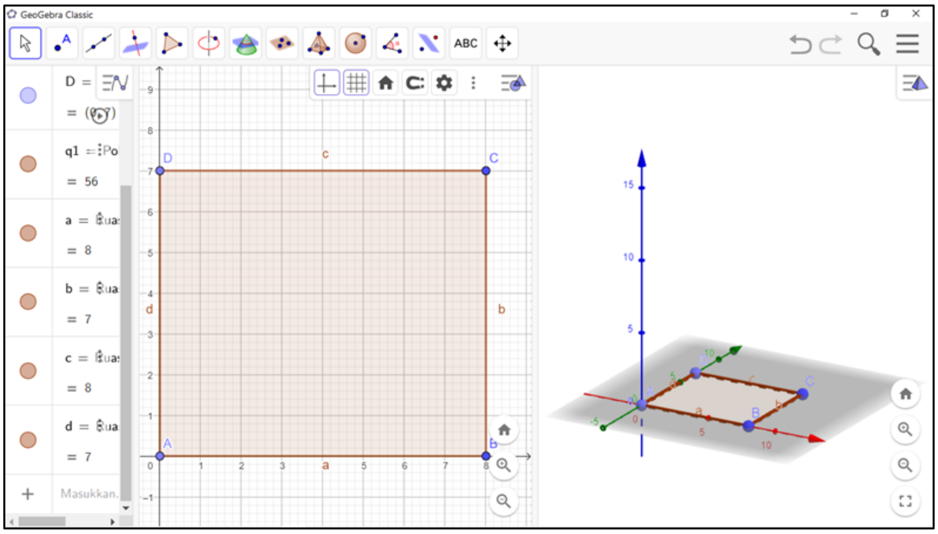

Fig. 22. Length and width specifications

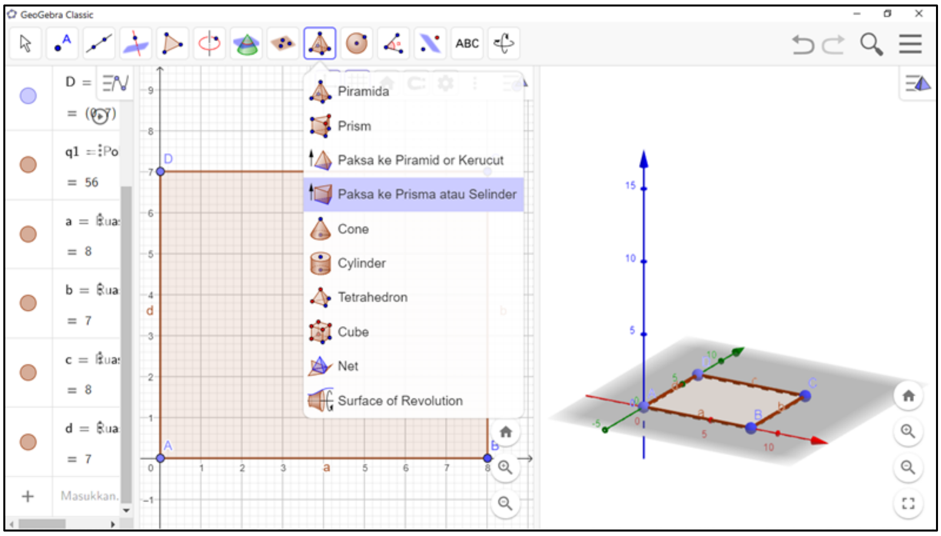

Fig. 23. use the "Force to Prism or Cylinder" tool to create a block shape

f. After that, click on the square in the three-dimensional graph to bring up the display like Figure 24. Then, fill in the height with the specified value of 15 cm, and then click OK. As a result, it will resemble the Figure 25. And then, change the parameters for values and coordinates to make it look neat by clicking on the tool  and selecting "Algebraic Formulation" and "Value", as shown in the Figure 26.

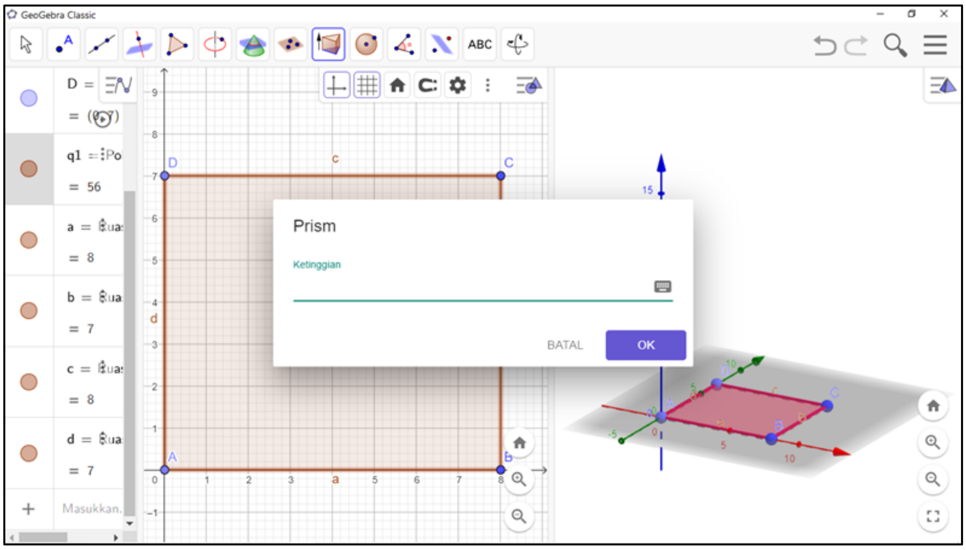

Fig. 24. Three-dimensional graph

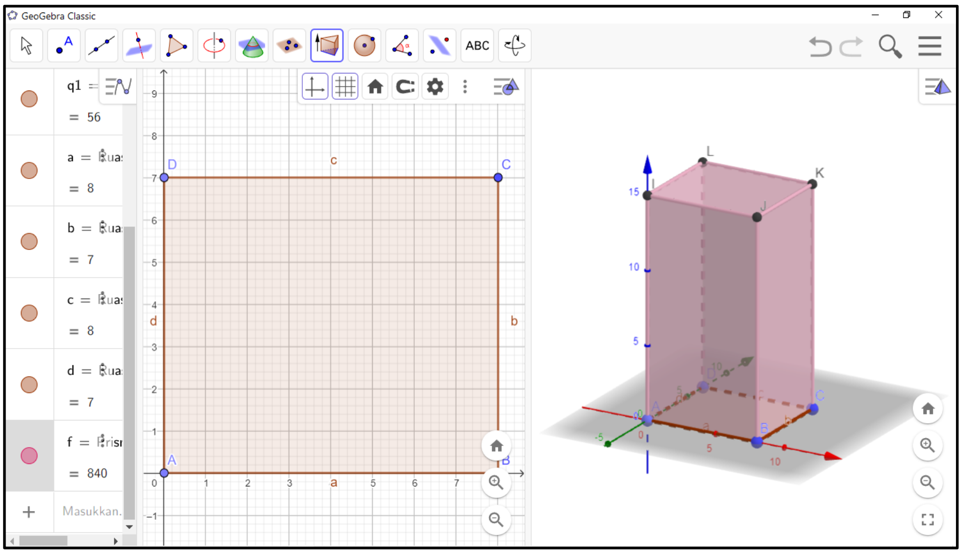

Fig. 25. Three-dimensional graph

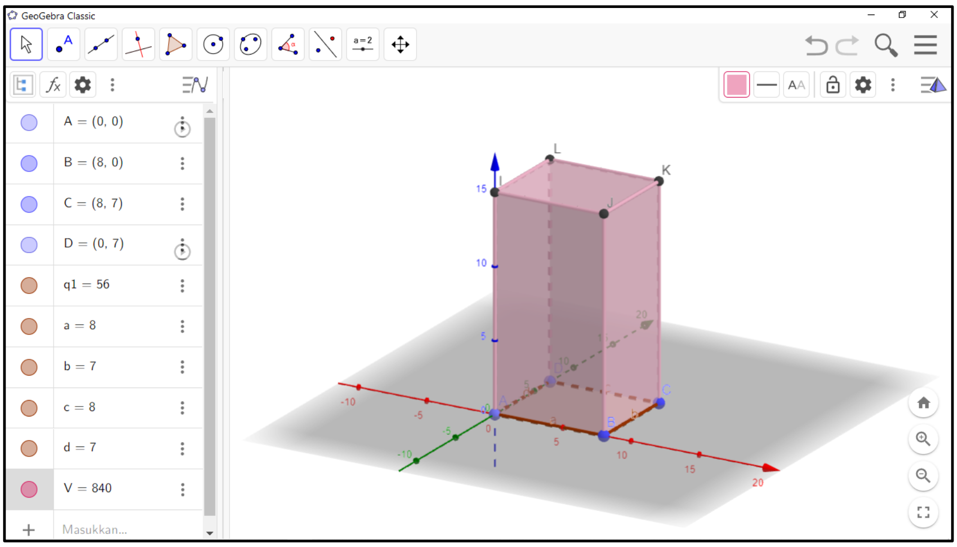

Fig. 26. Three-dimensional graph

Students redrew quadrants and rectangles using GeoGebra by arranging them within the selected theme. This software ability to replay a given construction and rethink the didactic process of working with pupils in advance is one of its strengths. Additionally, researchers can scrutinize solutions and utilize software to observe constructions in operation.

Open-ended problems foster mathematical creativity through the exploration of contexts, software features, and mathematical concepts [47,48]. Mathematical creativity can be fostered through a deliberate exposure to problem formulation, divergent thought, and original strategies [49,50]. Overall, mathematical creativity can be fostered through intentional experiences, the recognition that all students are creative, and the application of effective learning strategies.

4. Conclusions

This article offers several helpful suggestions for fostering the student inventive mathematical reasoning. The problem-based learning approach encourages critical thinking, collaboration, and the development of novel solution-creating strategies. Students can see new patterns, generate creative ideas, and think beyond conventional paradigms when given open-ended tasks. The use of technology, such as interactive software and mathematics applications, offers engaging learning experiences and facilitates the visualization of complex concepts. Geogebra, as described in this article, is a tool that can assist students in developing their inventive thinking abilities. Affirming and appreciating student creative ideas strengthen their ability to think creatively. The implementation of these suggestions is to aid students in developing creative problem-solving skills that are applicable to solve complex math problems and face real-world challenges.

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