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Digital Transformation in Learning: Optimizing Computational Thinking Ability through Utilization of Geogebra

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Abstract. Educational activities in the information technology era have changed from time to time. These changes are both challenges and opportunities, especially in the educational process. So that changes that occur in the learning process require learning strategies in accordance with the development of information technology. There are several learning strategies that can be carried out in the digital era, including carrying out innovations and evaluations with digital GeoGebra media. The research method of writing this is a literature study of research results that have been published. This study aims to determine the effect of using GeoGebra in optimizing the ability to think computationally. Computational thinking skills are defined as mental activities to abstract problems and formulate solutions to these problems that can be automated. Based on the results of the research above, it can be concluded that students can work on questions by utilizing Geogebra Software seriously and enthusiastically in the learning process, and students can also find their own solutions to problems with the help of Geogebra software.

Keywords: " Learning, Technology, GeoGebra, Computational Thinking"

1. INTRODUCTION

The 21st century demands human resources to have many skills. One of the challenges is in the world of education to design or provide human resources capable of facing global competition. The Indonesian Ministry of Education and Culture in 2017 stated that there are four competencies that students in the

21st century must have called 4C, namely critical thinking and problem-solving (critical thinking and solving problems), creativity (creativity), communication skills (ability to communicate) and ability to work collaboratively (ability to work together).[1] Thus, the purpose of 21st-century education is not only to prepare simple students but to produce students who have these four competencies. Based on the explanation above, critical thinking and problem-solving (critical thinking and solving problems) are one of the abilities that must be mastered by students.

In everyday life, it often happens that learning still looks monotonous and does not lead students to think critically. In learning mathematics for example. Meanwhile, in learning mathematics students should be trained to think critically and be able to solve problems. This is because learning mathematics is one aspect of education that has an important role in shaping one's thinking skills and logical skills. The application of procedural learning techniques results in students not being able to understand the concept properly. PISA (Program for International Student Assessment) is one of the main assessments on an international scale that assesses students' mathematical abilities.[2] The 2018 PISA survey assessed 600,000 students aged 15 from 79 countries. Based on the survey, it was found that the mathematical ability of Indonesian students was 379, ranking 7th from the bottom, while the average OECD member country for mathematics and science was 489.[3] The acquisition of this value shows that the mathematical abilities of Indonesian students are very low. That means the ability and application of mathematical communication, problem-solving, and reasoning of Indonesian students are still not optimal.[4] So by looking at the results of the PISA, Indonesia is required to reflect and improve itself in order to improve the mathematical abilities of students in Indonesia.[5,6]

Soedjadi argues that the basic objects of mathematics are facts, concepts, relations/operations, and principles which are abstract things so understanding them is not enough just to memorize but requires a thought process.[7,8] Meanwhile, Santrock states that the process of thinking is manipulating or managing and transforming information in memory. Thus, learning mathematics should emphasize the thinking process of students so that they can get used to processing and transforming information to solve a problem. Therefore, students' thinking abilities become one of the benchmarks for achieving mathematics learning objectives, for example, such as high-order thinking skills, critical thinking skills, creative, computational, logical-analytic, and reflective.[9,10]

One of the thinking skills that must be mastered by students is the ability to think computationally (computational thinking). Computational thinking is a cognitive skill that allows educators to identify patterns, solve complex problems into small steps, organize and create a series of steps to provide solutions and build data representations through simulation.[11] Computational thinking techniques are very important to master in learning mathematics because it trains to be able to solve problems and find solutions. Not only in learning mathematics but computational thinking skills are also needed in the world of work. As Wing argues, computational thinking is not only important for those who want to pursue a career in technology or computing but can also help someone in a variety of other fields.[12,13]

Computational thinking techniques according to Ioannidou (2011: 4) can be described as follows: decomposition, pattern recognition, pattern and abstract generalization, and algorithm design. Decomposition is the ability to break down complex tasks (problems) into small, more detailed tasks (problems). Pattern recognition is the ability to recognize common similarities or differences in order to make predictions, for example, to recognize number patterns. Pattern generalization and abstraction are the ability to filter out unnecessary information and draw generalizations based on the information received so that these results can be used to solve similar problems. Algorithm design is the ability to arrange the stages of problem-solving.[14]

As is often seen, learning mathematics in schools still uses procedural learning methods. And this is not effective in motivating water students to be able to identify and solve problems. In this case, there is one medium that can help students improve their computational thinking skills, namely the GeoGebra application. According to Ekawati (2016), GeoGebra is a dynamic mathematical software that combines geometry, algebra, and calculus. Hohenwarter & Fuchs (Nopiyani, Turmudi, and Prabawanto, 2016) said that GeoGebra is very useful as 1) demonstration and visualization media; 2) construction tools; 3) discovery process aids; and 4) means of communication and representation.[15]

One example of mathematics learning material that can be solved using GeoGebra is spatial geometry. GeoGebra was developed in 2008-2009 at Florida Atlantic University by Markus Howenwater. GeoGebra is a multi-representational application, which has an algebraic display, a graphical display, and a numerical display, according to Nur (2016).[16] This is in line with Shandy Agung (2018) stating that GeoGebra is a computer software that can visualize mathematical objects quickly, accurately, and efficiently. By using this GeoGebra application, students are able to visualize mathematical concepts to become more concrete and motivate students to be able to identify and solve problems in learning mathematics.

Based on the description above, the reason researchers raised this problem was in an effort to improve students' computational thinking abilities by using GeoGebra applications on linear equation material. For the formulation of the problem, how effective is the use of GeoGebra media in increasing students' computational thinking skills in learning mathematics? What are the challenges or obstacles that might be faced in using GeoGebra in learning to optimize students' computational thinking skills?

2. METHOD

The research method of writing this is a literary study of research results that have been published in national and international journals. A literature study is a series of activities related to methods of collecting library data, reading and taking notes, and managing research materials, involving systematic steps to collect, evaluate, and synthesize information from various literary sources relevant to the research topic.

Another understanding of the study of literature is to look for theoretical references that are relevant to the cases or problems found. These references can be searched from books, journals, and research report articles. The output of the literature study is the collection of references that are relevant to the formulation of the problem. The results of the research study regarding the ability to think computationally by utilizing GeoGebra during 2013-2023.

After collecting several related journals, then analyzing the data using descriptive qualitative analysis through literature study, the results of the analysis are in the form of descriptive data in the form of written sentences and the observed behavior results from the results of research conducted by previous researchers.[13]

This study aims to determine the effect of using GeoGebra in optimizing the ability to think computationally by reciting, recording, and managing journals that are relevant to GeoGebra and computational thinking skills as well as journals that show the effect of learning with the use of GeoGebra in improving computational thinking skills.

3. RESULT AND DISCUSSION

This article is written to see and provide examples of the application of mathematical computational thinking in geometric material using GeoGebra media. The author presents a brief explanation of the geometry to be discussed, namely the tube. And the elaboration of other points that will be discussed such as computational thinking, computational thinking indicators, and GeoGebra. Apart from the elaboration of the points mentioned above, the results will explain how effective the use of the GeoGebra application can improve students' mathematical computational thinking skills as well as the challenges or obstacles that may be encountered in using the GeoGebra application.

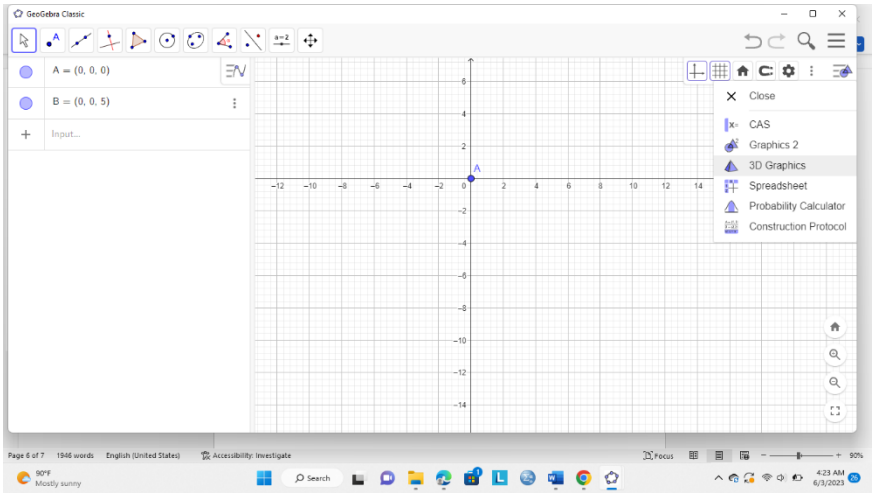
3.1. Result

Use of GeoGebra in spatial geometry

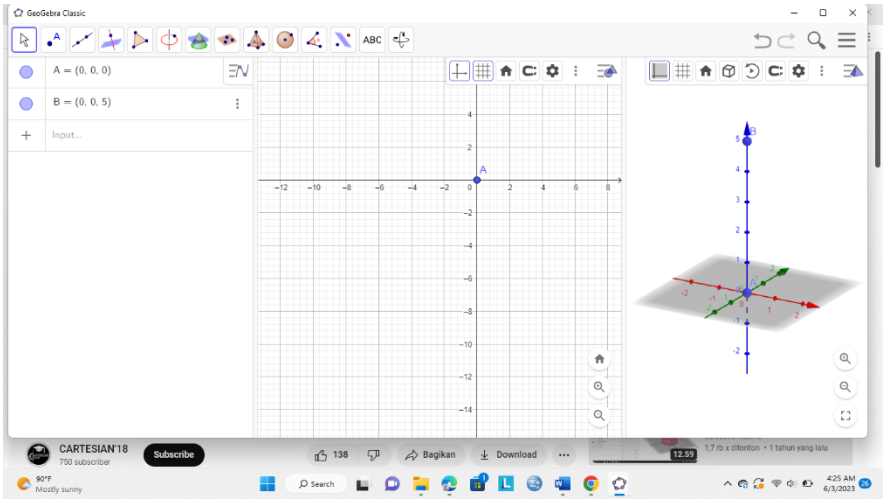
In this article, the researcher will provide an example of using the GeoGebra application in space geometry material in finding the volume of a cylinder.
The tube is a geometric shape that has curved sides and consists of 3 sides and two ribs. The side planes on the tube are located on the base or bottom of the tube which consists of 1 side and 1 more side located on the curved plane of the tube space. It turns out that the curved plane in the tube is often known as the tube blanket because it covers the "body" of the tube. One more thing, the side of the tube is located at the top of the tube or more commonly known as the tube cover.
The volume in the cylinder shape can be calculated by the following formula
V = Base area x height
V = π x r2 x t

Here's how to draw a tube using GeoGebra:

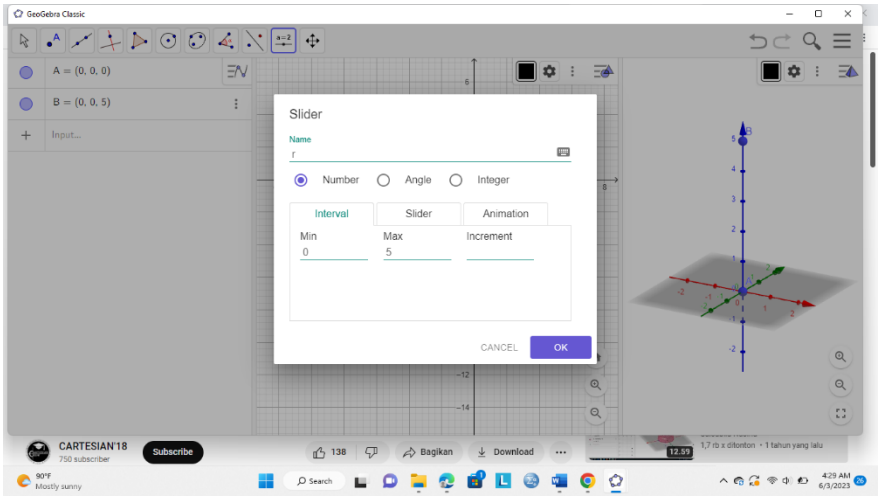
1. Type A (0,0,0) and B (0,0,5) on the input menu display. Then, click the menu to the right, dot three, and click 3D Graphics.



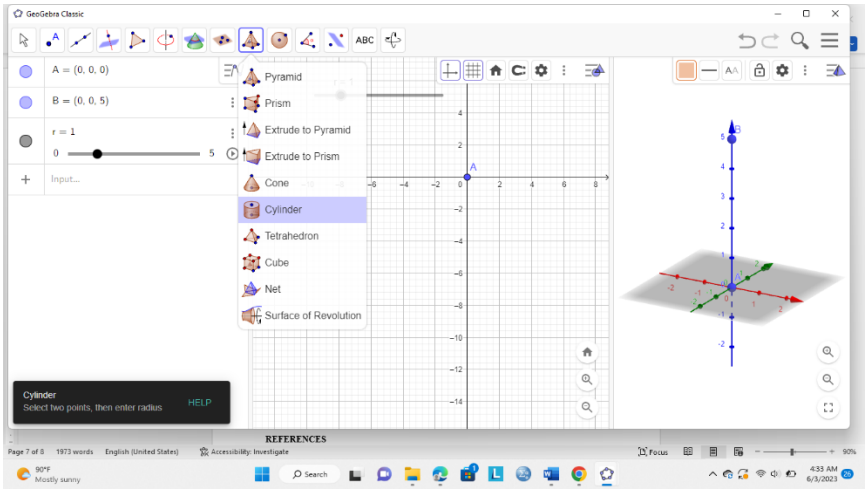
2. Next a display will appear as below.



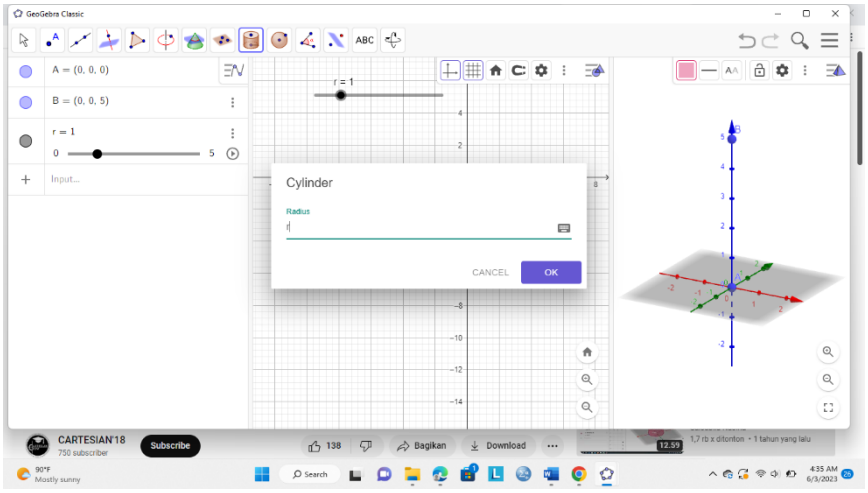
3. In the two-dimensional graphics section, click "slider" and input as shown below



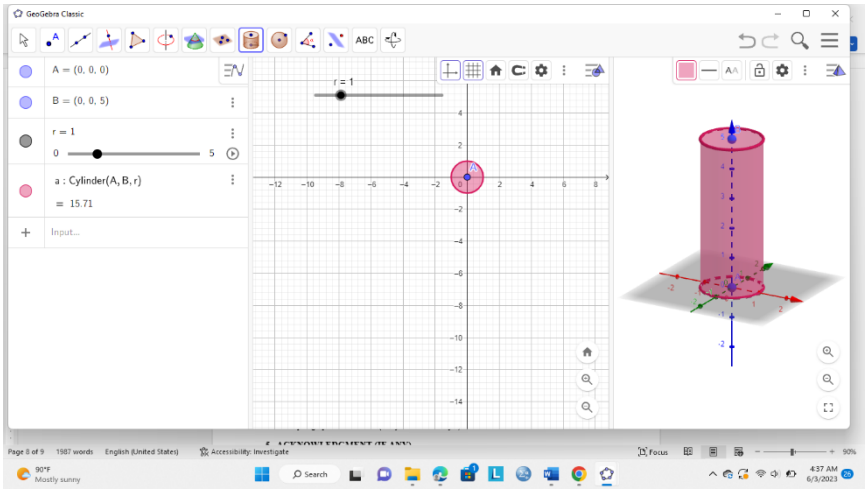
4. On the three-dimensional graph, click the "cylinder" menu.



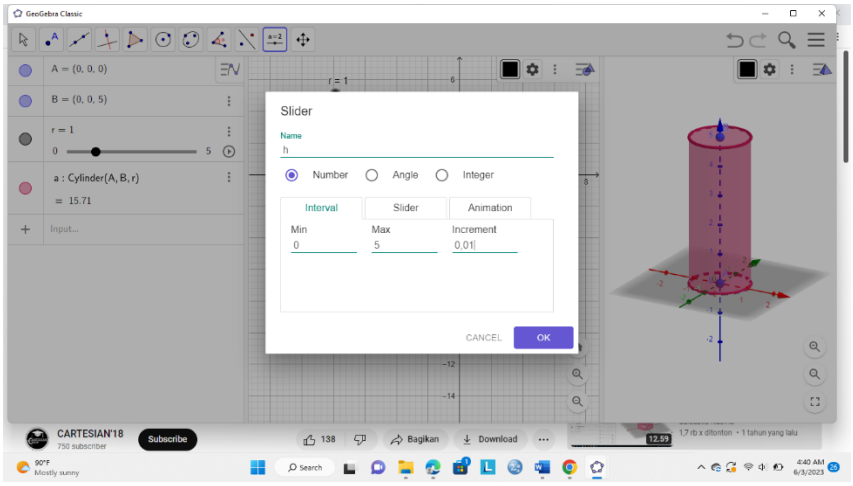
5. Next, cl ick point A to point B and name it r.



6. And it will look like the following.

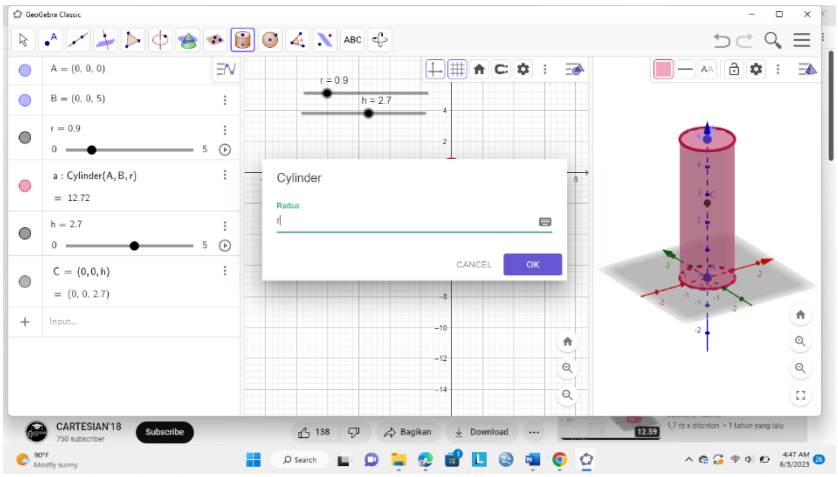


7. Click the slider on the two-dimensional graph and input the numbers as below

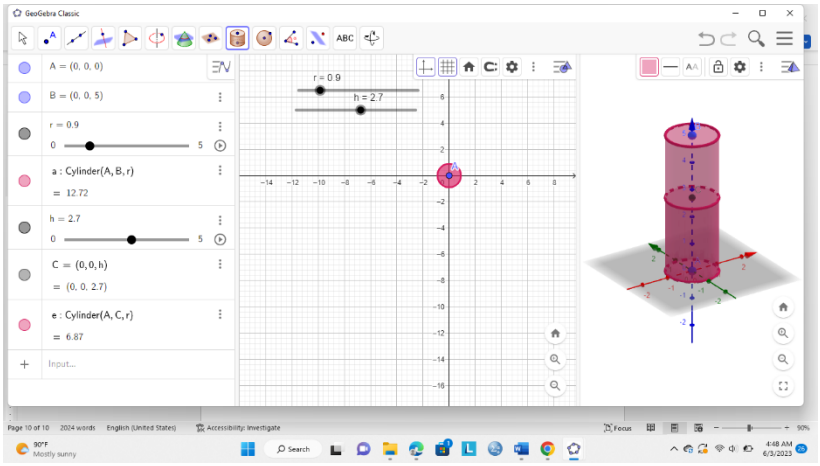


8. Input C = (0, 0, h)

9. On the three-dimensional graph, click the 'cylinder' menu again and name it r.



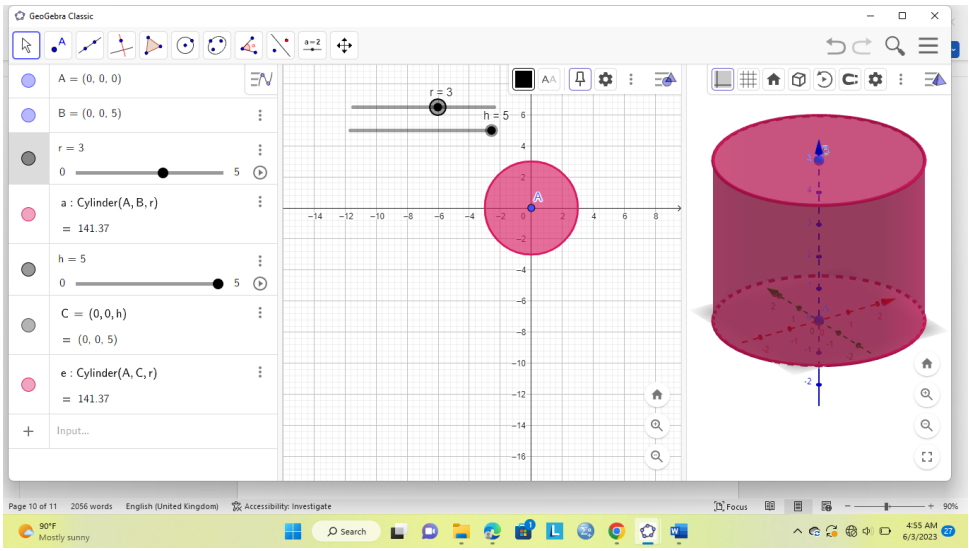
10. And the tube image has been formed.



An example of applying the volume of a cube to GeoGebra:

If it is known that the radius of the tube is 3 cm and the height of the tube is 5 cm. Determine the volume of the tube!

To find out the volume of the cylinder, we only need to shift the points r and h at the point asked for the question. And the volume of the tube will appear, which is 141.37 cm.



Achievement indicators think computationally in using the GeoGebra application to find the volume of a cylinder.

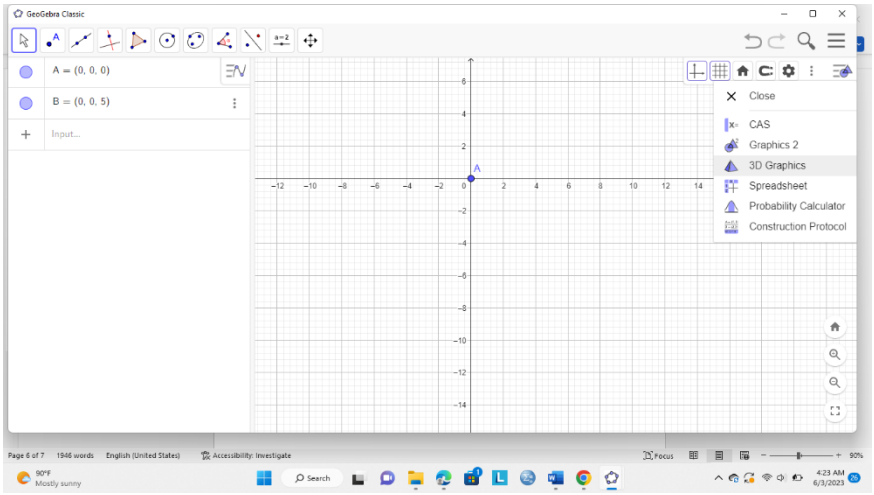
1. Decomposition

To solve a math problem, the first thing to do is to read and understand the problems that arise in the questions. In this case, students must simplify the problem into small parts that are easy to understand.[17]

If it is known that the radius of the tube is 3 cm and the height of the tube is 5 cm. Determine the volume of the tube!

In the example problem above, students are able to read that the radius of the tube or which can be symbolized by r which is mentioned in the problem is 3 cm and the height of the tube which can be symbolized by t is 5 cm. And students are asked to find the volume of the cylinder.

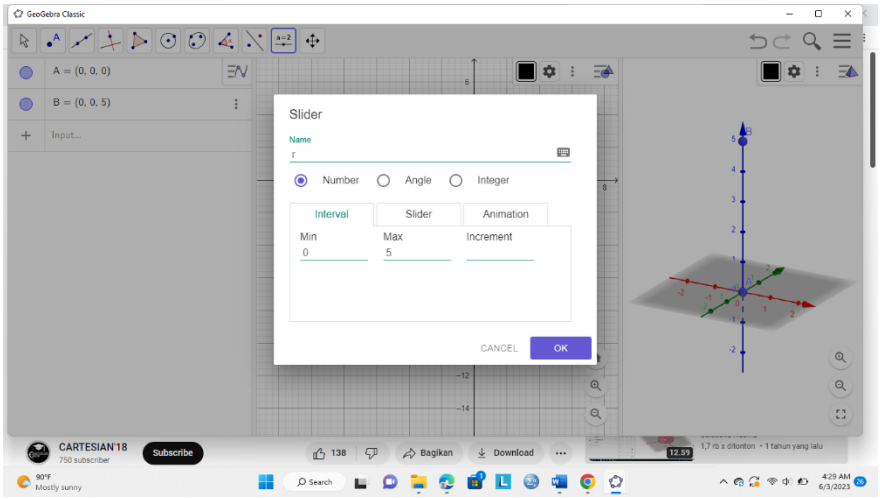
This first step is the decomposition stage, where students make center points at A (0,0,0) and B (0,0,5) on the input menu display. Then, click the menu to the right, dot three, and click 3D graphics



2. Pattern recognition

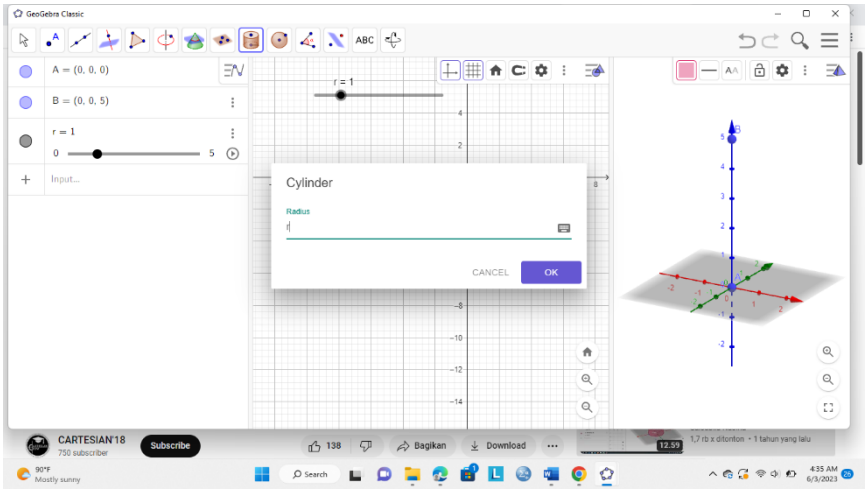
In this indicator, students are expected to be able to develop and understand the pattern for the steps to be used.[17] With the same example problem, students can understand how to find the volume of a cylinder, the radius, and the height of the tube are needed.

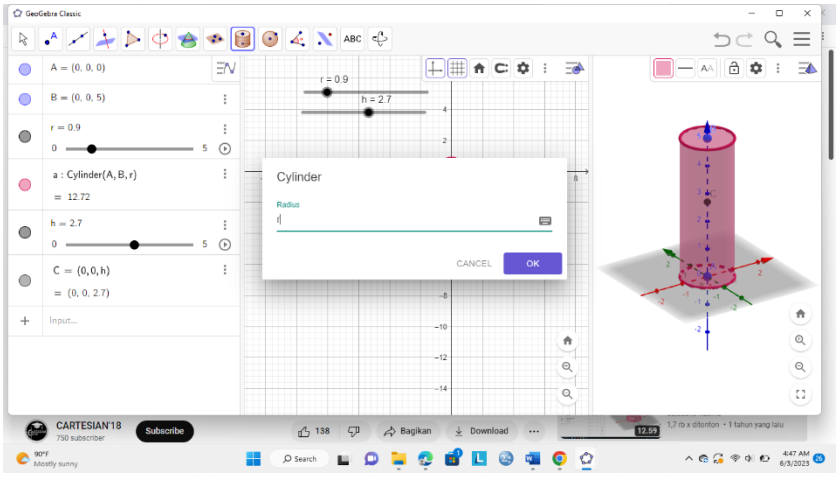
In the third step of using GeoGebra, in the maximum menu, enter 5 because the height requested for the question is 5.



3. Thinking Algorithm

This relates to algorithmic thinking skills by making it easier for students to analyze and prepare steps to solve problems.[17]

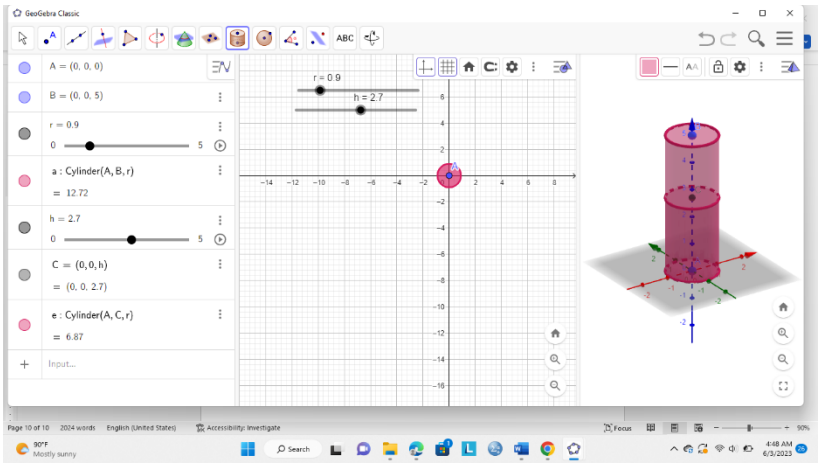




At this step, students have thought of an algorithm and will make it easier for the next step.

4. Generalization of Patterns and Abstractions

Students can use fast ways to solve problems based on previously obtained data. In line with the statement (Cahdriyana & Richardo, 2020) which states that the pattern recognition section is useful for strengthening ideas on abstraction indicators. [17]



When the concept has been formed, students only need to adjust the size of the radius and height of the tube asked for by the question. Automatically the cylinder volume will immediately appear on the application screen display

The results of relevant research state that teachers feel helped by the software because students can learn independently easily not only at school but also at their respective homes. By increasing student learning motivation, teachers feel more optimistic about improving student learning outcomes.

Based on research conducted by Dara Kartika Dewi, et al (2020) with mathematics learning assisted by the GeoGebra application on Geometry Transformation material, it was concluded that students were

interested in learning indicators and almost all students had positive responses. enthusiastic. In addition, it is easy to access the GeoGebra software, namely via a computer or smartphone so that it can be used easily anywhere and anytime. Broadly speaking, students and teachers have no difficulties and feel helped with the help of the GeoGebra software.[18]

The advantages of GeoGebra are (1) being able to visualize objects so that students can reduce the level of abstraction on a material, (2) GeoGebra can be used as an aid in solving math problems, math learning media, and tools in making teaching materials mathematics. (3) easy and free access, (4) easy to analyze the characteristics that exist in something geometric objects, and (5) the existence of animation and manipulation movements that provide visual impact on students so that students are able to understand the concept of geometry clearly. Weakness GeoGebra is not all math material can be applied in GeoGebra and for to use GeoGebra must have a device (computer or smartphone).[19]
Based on research conducted by Muhammad Rizaldi Juliansyah in his thesis entitled, Computational Thinking of Students based on Gender with the AIR Learning Model assisted by GeoGebra by taking questionnaire data from 15 respondents randomly there are indicators of the effectiveness of GeoGebra, namely as follows;
1. Cognitive aspects
a. Problems can be solved
Based on the results of his research, by using GeoGebra students are able to solve problems efficiently because it doesn't take a long time to solve problems percentage of 74.45%.
b. Retention of material
GeoGebra itself is able to visualize objects, symbols, and equations in material mathematics clearly (Umayah & Evendi, 2018). And the results of his research, as much 68.89% of students are able to understand the material well.
c. Feelings of joy following learning
By using a response questionnaire in his research, it turns out that GeoGebra can increase students' interest in learning mathematics by a percentage of 77.08%.
2. Material aspects
a. Media can explain the material
GeoGebra can provide illustrations of geometric objects (tubes, cones, and balls) on the material studied in class, namely the material of curved side shapes. GeoGebra can also solve for the surface area and volume of shapes with enter the formula into the input. Thus, the presentation of GeoGebra in explaining matter is 83.33%.
b. Compatibility with the material
Curved side shape materials can be applied to GeoGebra media. So the suitability of the material can help students to understand the material being studied. The indicator of the suitability of the media with the material gets a percentage of 71.11%.
c. Learning is more interesting
Learning that is not monotonous can increase students' interest and motivation in learning learn math. This indicator gets a percentage of 71.67%.
3. Media aspect
a. Animation display quality
GeoGebra can clearly visualize objects, symbols, and mathematical equations and can reduce the level of abstraction in mathematical material. In this case, GeoGebra can help students improve the learning process. The percentage reached 72.78%.
b. Easy to operate
GeoGebra can be accessed online through the website or offline with download the app. The percentage reaches 70%.
c. Caption readability

GeoGebra provides users with visualizations to display objects clearly and realistically. The objects displayed by GeoGebra can help students understand curved side building materials, especially what are the characteristics contained in each geometric shape such as a cylinder, cone, and cylinder. This indicator gains a percentage of 76.11%.[19]

3.2. Discussion

Think computing

Computational thinking is a cognitive skill that allows educators to identify patterns, solve complex problems into small steps, organize and create a series of steps to provide solutions and build data representations through simulation. [7] Computational thinking is a way for someone to formulate a problem by breaking down the problem into smaller and more manageable parts, in other words, computational thinking is a series of activities that involve a set of skills and techniques to solve problems.[20] Based on this understanding of computational thinking, it can be seen how important this ability is to face 21st-century life which focuses on the digital role. Therefore, this ability should be built by students as early as possible through formal education.

Computational thinking skills are defined as mental activities to abstract problems and formulate solutions to these problems that can be automated. Society's life is currently based on digital information, therefore the ability to think computationally is an important ability for everyone. To ensure that students are able to master these skills, it is important for teachers to incorporate them into the learning process at school.

Lockwood & Mooney (2017:15) states that integrating computational thinking in the education sector provides benefits including 1) improving analytical thinking skills students, 2) enabling students to have a better understanding of programming, that the goal is solving the problem and not just about the code, 3) fixing the views students about programming and encourage their self-confidence, 4) can be used as a clear indicator of academic success, this is because the computational thinking score has strong correlation with general academic success.[21]

Computing thinking indicator

Indicators of computational thinking skills refer to 4 aspects of computational thinking skills, namely 1) problem decomposition, 2) algorithmic thinking, 3) pattern recognition, and 4) abstraction and generalization.[22]

Indicators of computational thinking skills (Cahdriyana & Richardo, 2020), which include:

Computational Thinking Skills	Indicator
Decomposition	Students are given information on how to simplify a problem by dividing it into parts that are easy to understand.
Pattern recognition	Students are directed to be able to develop and understand the pattern for the steps to be used.
Algorithmic Thinking	This relates to algorithmic thinking skills by making it easier for students to analyze and prepare steps to solve problems.
Generalization of Patterns and Abstractions	students are advised to be able to use a fast way to solve problems based on data obtained previously.

GeoGebra

GeoGebra is a freely accessible mathematical software that is quite complete and can be used to solve geometry, algebra, and calculus problems (Haciomeroglu, Bu, Schoen, & Hohenwarter, 2009). GeoGebra was first developed by Markus Hohenwarter from Austria and the name GeoGebra is an

abbreviation of geometry (geometry) and algebra (algebra) (Tamimuddin & Nurul, 2013). The advantages of the GeoGebra application as quoted in Fazar (2015) include: easy to use, quite complete features for learning mathematics, supports web platforms, supports various operating systems, is available in various languages, is open source, and is free. According to Hohenwarter & Fuchs (2004), GeoGebra is very useful as a medium for learning mathematics with a variety of activities as follows.
1. As a demonstration and visualization medium. In this case, in traditional learning, teachers use GeoGebra to demonstrate and visualize certain mathematical concepts.
2. As a construction aid in this case GeoGebra is used to visualize the construction of certain mathematical concepts, for example constructing the inner circle or outer circle of a triangle, or a tangent line.
3. As a tool for the discovery process in this case GeoGebra is used as a tool for students to find a mathematical concept, for example, the position of dots or the graphical characteristics of a parabola.[23]

The use of GeoGebra should be utilized to support self-learning processes because the features provided by GeoGebra are quite complete, it's just how teachers can make media and mix them in the learning process.

The main menus of GeoGebra are File, Edit, View, Options, Tools, Windows, and Help for drawing geometric objects. The File menu is used to create, open, save, and export files, as well as exit programs. The Edit menu is used to edit paintings. The View menu is used to set the view. The Options menu is for adjusting various display features, such as setting font size, setting the type (style) of geometric objects, and so on. Meanwhile, the Help menu provides technical instructions for using the GeoGebra program.[23]

1. CONCLUSION

Based on the results of the research above, it can be concluded that students can work on questions by utilizing GeoGebra Software seriously and enthusiastically in the learning process, and students can also find their own solutions to problems with the help of GeoGebra software. Information was obtained that they felt happy and helped by the GeoGebra Software in solving spatial geometry problems. In addition, it is easy to access the GeoGebra software, namely via a computer or smartphone so that it can be used easily anywhere and anytime. In general, students and teachers experience no difficulties and feel helped by the help of the GeoGebra software. As well as students can also find their own solutions to problems with the help of GeoGebra software which can optimize students' computational thinking.

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