The Potential of GeoGebra Exploration in Supporting Multiple Representation Ability

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Abstract The ability of multiple representations is an essential ability to solve problems in learning mathematics. Problems in learning mathematics are still a matter of material that is too abstract. The way to reduce the abstractness is to convert them into representations that are easier to understand. In learning mathematics, there is software that can provide various forms of representations (symbolic, visual, and verbal), namely GeoGebra. The purpose of this study is to describe the ability of multiple representations through the potential of GeoGebra exploration. This study uses quantitative and qualitative methods (mixed methods) with convergent parallel strategies. Data taken through tests, response questionnaires, and observations. The results show that the ability of multiple representations that appear in the form of symbolic, visual, and verbal representations with the percentage of students sequentially by 81%, 100%, and 81%. This is supported by the results of a positive student response questionnaire to the potential of GeoGebra exploration regarding student interest in learning mathematics when using GeoGebra and the ability of students to display multiple representations of mathematical material through GeoGebra.

1. Introduction
The National Education Standards Agency or BSNP [5] states that mathematics is one of the sciences that is the basis of developments in people's lives and is needed in technological development. Mathematics can be basis of the development of people's lives and technological developments because there are abilities in mathematics which include: (1) mathematical communication, (2) mathematical reasoning, (3) mathematical problem solving, (4) mathematical connection, and (5) mathematical representation [22]. According to [15], representations consist of: (1) verbal representations, (2) diagrams, (3) graphical representations, and (4) mathematical representations. These representations are needed when students solve quantitative problems using equations that are following the information obtained. According to [6] through various representations, understanding concepts can be instilled in students. The use of diverse representation in resolving a problem, it can be called a multi representation or representations multiple.
Multiple representations are the ability to present concepts in different ways [8]. Multiple representations can also be defined as the process of visualizing and concreting abstract concepts or symbols in everyday life in general form, and also the definition of relationship between objects or symbols in mathematics [12]. Based on these notions, it can be concluded that multiple representations are the delivery of a concept in a certain format or various forms. The importance of the multiple representations ability can also be seen from the results of previous studies. The results of research in 2008 by Kohl, et.al stated that the ability of students who learn to use multiple representation strategies is better at solving problems than students who do not use multiple representation strategies [15]. Mathematics teachers need to consider and effectively use multiple representations in the form of verbal, numerical, visual graphics, with the support of technological development rather than only using verbal and intensive mathematical language [13].

Technology can be used as a learning media, according to [20] referring to the multimedia principle, students learn better when using words and pictures rather than just using pictures or words. This principle is also in line with the theory of multiple representations [20]. Related to certain material, learning new arithmetic procedures with multiple representations might be tiring for novice students [21], especially when asked to choose, organize, and integrate multiple representations with prior knowledge and without guidance [24]. For multimedia learning to be effective, it is important to design the material in a way that maximizes students’ opportunities to actively choose, organize, and integrate multiple knowledge representations. The results of the study mentioned, the difference in treatment of students studied showed that in learning mathematics using media or games with interactive multiple representations enables ideal learning situations such as bringing students to a high level of computer skills and to emphasize the importance of giving time to think of solutions before trying to answer an problem [20].

It appears that multiple representations are very closely related to the use of multimedia or computer technology. According to [1] software such as computers with multiple representations in learning in schools can provide positive benefits. Supported by appropriate learning conditions and teacher involvement. Technology is also one of the most powerful tools in the 21st century. Technological developments have penetrated various fields, including education. The National Council of Teachers of Mathematics, NCTM, [20] confirms that technology is a very important tool for learning mathematics in the 21st century today, and all schools must ensure all students have access to technology. Also, when technology is used strategically, it will facilitate mathematics learning for all students. According to research from [2], an increase in student achievement test scores is likely due to their attractiveness to technology. The development of technological tools increases students’ interest in finding out new things. Students tend to explore the world of technology to apply it in mathematics learning. Students’ interest in technology in learning is also shown in the research of [3] which states that students have a positive perspective on learning mobile blended mathematics using smartphones.

One form of technology in mathematics is GeoGebra software. According to [16], GeoGebra is a piece of software that is open source and can support the learning of various mathematical concepts dynamically that present concepts well through modern views of knowledge construction. Besides, GeoGebra is a highly interactive container that also provides various types of information (text and numbers) and feedback (intrinsic visual and extrinsic numeric) to facilitate the formation and verification of conjectures and corrections of the construction that has been made.

GeoGebra was first developed in 2001 by Markus Hohenwarter. According to [11] GeoGebra is a dynamic mathematical software that combines geometry, algebra, and calculus. GeoGebra display generally consists of the main menu, toolbar, algebraic display, graphic display, and input bar. The following uses of GeoGebra in mathematics learning [11]: (a) GeoGebra for demonstration, simulation, and visualization, (b) GeoGebra is used as a construction aid, (c) GeoGebra is used for mathematical exploration and discovery. GeoGebra’s dynamic worksheet can support students to explore and understand certain concepts, relations, and principles in mathematics. Based on the importance of multiple representation ability, its close relationship with the use of technology, as well
as the presence of functions of GeoGebra technology that can support the emergence of multiple representations. Then this article will describe the ability of multiple representations through the potential of GeoGebra exploration.

2. Method

This study uses qualitative and quantitative methods (mixed methods) with parallel convergent strategies, namely by placing qualitative and quantitative methods in activities carried out together or simultaneously. Then compare the two methods, and end with interpretation. The subjects of this study were 32 students of Class VIII C of SMP Negeri 4 Depok. Students were previously taught using the GeoGebra program adapted from Kusuma (2017). The material used is polyhedron, especially a cube. Students learn about the elements, webs, and surface area of a cube. In the material of cube elements, students explore the shape of a cube by selecting one of the cubes until it is selected so that it gives rise to information about the selected cube section. Then students went to the material in cube nets. At first, students are faced with buttons that will direct students to the understanding of the net. Then students choose nets to form a cube, it will be raised understanding of the nets of the cube, the number of cube nets, as well as an example of one of the cube nets that can be driven to form a cube. Finally, looking for the surface area of the cube, students are directed to find out the understanding and how to calculate the surface area of the cube by visually and symbolically adding the area of each cube, then students deduce the formula of the cube surface area.

Data collection techniques in this study were to test multiple representations ability, questionnaires, and observations. The instrument of data collection was in the form of 2 item test questions and questionnaire responses for students. The description test aims to measure the ability of multiple representations of students on the material to build a polyhedron, especially to build a cube, each question has aspects that refer to the ability of multiple representations. Indicators of the measured of multiple representations ability are using symbolic representations to explain mathematical ideas and make the move from visual to verbal representation, visual to symbolic, verbal to symbolic, or vice versa. The first problem indicator is solving a problem related to calculating the surface area of a cube if the length of the edge is extended to twice the length of the original edge. The second question indicator is that students can write the steps to determine the minimum amount of paper needed to wrap a cube-shaped gift box.

Instrument questionnaire students' responses to the use of GeoGebra software on the material to polyhedron. This questionnaire aims to determine students' responses to the potential for GeoGebra exploration regarding student interest in learning mathematics when using GeoGebra and the ability of students to display multiple representations of mathematical material through GeoGebra. This questionnaire was adapted and modified from a questionnaire statement contained in [6]. The questionnaire statement was modified according to the conditions of the students in this study. The questionnaire consisted of 18 statements which were subdivided into 12 positive statements namely statement number 1,3,4,6,7,8,10,11,12,16,17,18 and 6 negative statements namely statement number 2,5,9 , 13,14,15. Students are asked to fill out a questionnaire by putting a checkmark in the choice column consisting of SS (Strongly Agree), S (Agree), N (Neutral/hesitant), TS (Disagree), and STS (Strongly Disagree). While the observation is made when students practice the GeoGebra program with attention to what course GeoGebra exploration program undertaken by students.

Data analysis techniques were carried out during and after data collection. The analysis steps are carried out with the following stages. First, during learning, observing the extent of exploration carried out by students when using the GeoGebra program. This activity was carried out as a whole and then selected the students who made the most exploration for further observation. Second, analyze the results of multiple student representation tests. The activities are: (1) checking the test results by giving a score at each step of the student's work based on the rules of scoring in accordance with the indicators that have been set; (2) giving the final test scores to each student; (3) classifying students' answers that satisfy the multiple representation ability categories, namely symbolic representations, visual representations, and verbal representations; and (4) counting the number of students in each category and changing it as a percentage.
Third, analyze student response questionnaire scores. Activities carried out in the form of (1) counting the total score of each item statement that has been filled out by students; (2) calculate the total score; (3) determine the maximum score, minimum score, median value, first quartile value, and third quartile value; (4) classify total scores in the categories of very positive attitudes, positive attitudes, negative attitudes, and very negative attitudes; (5) calculating the frequency distribution of the number of students in each category and changing it as a percentage; and (6) counting the number of students in each attitude category based on aspects of the questionnaire statement. Fourth, the conclude in the form of multiple representations ability of what are there and the percentage is supported by GeoGebra exploration potential that is seen from the results of student questionnaire responses.

3. Result and Discussion

3.1 Result

Indicators of the measured ability of multiple representations are using symbolic representations to explain mathematical ideas and make the move from visual to verbal representation, visual to symbolic, verbal to symbolic, or vice versa. The results of multiple representation ability tests based on the category of symbolic, visual, and verbal representations are shown in the following table.

| Table 1. Percentage of student's multiple representation abilities |
|---------------------------------------------------------------|
| Symbolic representation | Visual representation | Verbal representation |
| Percentage of students displaying representations | 81% | 100% | 81% |

Based on the results of this percentage, many students use symbolic representations of 81%, it can be said that almost all students can use symbolic representations. Examples of students who used symbolic representations are as follows.

**Figure 1.** Student’s answer who used symbolic representation

**Figure 2.** Student’s answer who not used symbolic representation

Based on the Figure 1. of the students’ answers, it appears that students use symbolic representations to explain mathematical ideas. Meanwhile, 6 students have not used symbolic representation. Examples of student’s answers that do not use symbolic representations are as follows. While from Figure 2., it can be seen that students do not use symbols to explain mathematical ideas. Students also do not transform from verbal to symbolic or visual to symbolic representation. The percentage of the number of students using visual representations is 100%. This indicates that all students use the ability of visual representation to solve a given problem. While the percentage of students using verbal
representations was 81%. Students transform the representation from symbol to verbal and visual to verbal. Examples of student answers that use this representation are as follows.

Based on Figure 3, students conclude with verbal representations after visual and symbolic representations. So, it can be concluded that overall students use the ability of multiple representations in the form of symbolic, visual, and verbal representations.

Testing using this questionnaire aims to determine students’ responses to the potential of GeoGebra exploration regarding student interest in mathematics learning when using GeoGebra and the ability of students to display multiple representations of material in flat-side space through GeoGebra. Data questionnaires filled out by students of class VIII C, which amounted to 32 people. After the data is collected, the data is analyzed to find out how much the students' response to the use of GeoGebra.

The results of the student response questionnaire based on a Likert summated rating analysis are categorized into four characteristics: a very positive attitude, a positive attitude, a negative attitude, and a very negative attitude [23]. The results of the analysis are shown in the following table.

| Attitude Category   | Frequency Distribution | Percentage |
|---------------------|------------------------|------------|
| Very Positive Attitude | 18                     | 56%        |
| Positive attitude   | 14                     | 44%        |
| Negative attitude   | 0                      | 0%         |
| Very Negative Attitude | 0                     | 0%         |

Students in the very positive attitude category numbered 18 people with a percentage of 56%. A very positive attitude is indicated by the acquisition of a total score between 72-90. Students in the positive attitude category were 14 people with a percentage of 44%. Said to be a positive attitude indicated by the acquisition of a total score between 54-72. While students with negative and very negative attitudes categories were not found in this study. It can be concluded that a very positive attitude and positive attitude are positive responses of students to the use of GeoGebra software. Examples of explorations carried out by students when use the GeoGebra program are as follows.
The students' performance is to look at the diagonal of the space on various sides. In visual representation, students become more able to imagine and understand more about what the diagonal space is like. Meanwhile, the verbal representation of students so they understand more understanding of the diagonal of space. In this display, there is also a transformation from verbal to visual representation or vice versa.

In Figure 5, the explorations conducted by students is to unite cube nets into a cube shape. In visual representation, students find it easier to imagine what the cube nets are like. In symbolic representation, students more easily understand that the surface area of a cube is the sum of the sides. So, the positive response of students reaches 100% and the explorations made by students in using GeoGebra indicate that students are very interested in learning mathematics using the GeoGebra program and students display multiple representations capabilities through GeoGebra.

3.2 Discussion

Multiple representation test results show that the representation used by students is in the form of symbolic representations with a percentage of 81%, visual representations with a percentage of 100%,
and verbal representations with a percentage of 81%. This indicates that students have used the ability of multiple representations to solve problems. The use of multiple representation capabilities by students is also supported by the results of a positive response questionnaire to the use of GeoGebra. The results of the questionnaire mean that the explorations made by students in using GeoGebra indicate that students are very interested in learning mathematics using the GeoGebra program and students display multiple representation capabilities through GeoGebra. Supported by the results of [2] which shows that students have positive perceptions of learning and better learning achievement using GeoGebra. The use of GeoGebra software can increase students' interest, confidence, and motivation in learning mathematics. Regarding its influence on the ability of multiple representations, [13] states that the use of multiple representations will be more effective if supported by technological development. GeoGebra is one of the technological developments in mathematics. [4] in their research concluded that GeoGebra is an effective tool for teaching and learning geometry in secondary schools.

According to [10], GeoGebra is a dynamic mathematical software whose basic ideas produce multiple representations. Also, according to [16], GeoGebra provides tools for creating multiple representations, both numerical and visual, such as geometric figures, tables, equations, graphs and calculations that can also be interrelated. Consider its influence on certain material, [25] state that GeoGebra as a dynamic software in mathematics allows its users to explore multiple representations of mathematical concepts.

4. Conclusions

The ability of multiple representations of students that emerged in this study was a symbolic representation with a percentage of students at 81%, visual representation with a percentage of students at 100%, and verbal representation with a percentage of students at 81%. The multiple representations ability of students is supported by positive responses from the results of student questionnaire regarding to the learning process using GeoGebra.

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