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Students' Creative Thinking Process in Mathematic Problems Solving Assisted by GeoGebra

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Abstract

The purpose of this research is to find out how students' creative thinking process in solving Geogebra-assisted math problems and to find out the obstacles experienced by students in the creative thinking process. This research is a qualitative descriptive research. The subject selection was taken 3 students using purposive sampling method, namely by considering students who were considered able to work on the math problems given and had been able to use GeoGebra. The data collection techniques used in this research were tests and interviews. The main instrument in this research is the researcher himself. Auxiliary instruments are math problems and interview guidelines. The math problem used is a spatial problem to find the volume and surface area with assisted by Geogebra to measure students' creative thinking. Interviews are used to find out how students' creative thinking processes while working on math problems. The analysis used is data reduction, data presentation and conclusion drawing. The results of this reasearch show the student's creative thinking process in solving math problems assisted by Geogebra. In this reasearch also shows that students experience obstacles at the stage of synthesizing ideas, namely the stage of students gathering information or remembering and combining ideas sourced from previous experiences.

Keywords: Creative thinking process, mathematic problems solving, geogebra.

Abstrak

Tujuan dari penelitian ini adalah untuk mengetahui bagaimana proses berpikir kreatif siswa dalam menyelesaikan soal matematika berbantuan Geogebra dan untuk mengetahui hambatan yang dialami siswa dalam proses berpikir kreatif. Penelitian ini merupakan penelitian deskriptif kualitatif. Pemilihan subjek diambil 3 siswa dengan menggunakan metode *purposive sampling*, yaitu dengan mempertimbangkan siswa yang dianggap dapat mengerjakan soal matematika yang diberikan dan telah dapat menggunakan GeoGebra. Teknik pengumpulan data yang digunakan dalam penelitian ini yaitu tes dan wawancara. Instrumen utama pada penelitian ini adalah peneliti sendiri. Instrumen bantu berupa soal matematika dan pedoman wawancara. Soal matematika yang digunakan adalah soal bangun ruang untuk mencari volume dan luas permukaan dengan bantuan Geogebra untuk mengukur berpikir kreatif siswa. Wawancara digunakan untuk mengetahui bagaimana proses berpikir kreatif siswa selama mengerjakan soal metematika. Analisis yang digunakan adalah reduksi data, penyajian data dan penarikan kesimpulan. Hasil penelitian ini menunjukkan bahwa bagaimana proses berpikir kreatif siswa dalam menyelesaikan soal matematika berbantuan geogebra. Dalam penelitian ini juga menunjukkan bahwa siswa mengalami hambatan pada tahap mensintesis ide-ide, yaitu tahap siswa mengumpulkan informasi atau mengingat dan memadukan ide ide yang bersumber dari pengalaman sebelumnya.

Kata kunci: Proses berpikir kreatif, Soal Pemecahan matematika, geogebra

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Introduction

Thinking is an activity that humans must do in their daily activities and to solve the problems they face. Ahmadi (2013) states that thinking is always related to problems arising from the present, the past, and perhaps problems that have not yet occurred, the process of solving these problems is called the thinking process. The thinking process occurs when a person is faced with an event related to something or information he knows. According to Kuswana (2011), the thinking process is an event of mixing, matching, combining, exchanging, and sorting concepts, perceptions, and previous experiences. Widyastuti (2015) also argues that the thinking process is a process that a person does in recalling the

knowledge that has been stored in his memory for one day to be used in receiving information, processing, and concluding something. So it can be said that the thinking process is a process of processing information, matching, combining and concluding by recalling knowledge from previous experiences that are used to face and solve the problem.

One of the high-level thinking skills is creative thinking. This is in accordance with the statement from King, Goodson, & Rohani (2009) that higher order thinking skills include critical, logical, reflective, metacognitive, and creative thinking. In today's industrial era, creative thinking is essential for students. Students' creative thinking ability must be developed because it is part of the life skills that must be possessed, especially in facing the era of information, industry, and increasingly fierce competition (Sumarmo et al., 2013). In line with that, the independent curriculum recognizes the importance of developing 21st century skills such as creativity, critical thinking, collaboration, and digital literacy (Rambung, 2023). Thus, in implementing the independent curriculum, students are encouraged to be more involved in an active and creative learning process. However, from the results of research by Andiyana (2018), related to the mathematical creative thinking skills of junior high school students on the material of building space, it is found that students' creative thinking skills are still low, especially in solving math problems. This can also be seen from the results of Indonesia's PISA survey in 2022, where Indonesia's math score is still relatively low at 366 which is below the international average of 489. PISA is an international study that assesses the quality of the education system in 81 OECD (Organization for Economic Cooperation and Development) countries by focusing on mathematical literacy, which is coupled with student analysis for creative thinking. In addition, the results of the TIMSS (Trends In Mathematics and Science Study) survey in 2015 also showed that the achievements of Indonesian students in mathematics were ranked in the bottom 6. Based on the above problems, researchers conducted research related to students' creative thinking process in solving math problems which aims to find out how students' creative thinking process in solving problems in order to find out what are the obstacles of students in creative thinking. So it is hoped that it can overcome these obstacles and improve students' creative thinking skills. In line with that, Kholisoh (2019) stated that one's creative thinking ability can be improved, one of which is by understanding the creative thinking process.

The creative thinking process is the stages that a person goes through when doing creative thinking activities. The creative thinking process is a process that combines logical thinking and divergent thinking (Siswono, 2004). Divergent thinking is used to find ideas to solve problems while logical thinking is used to verify these ideas into a creative solution (Siswono, Rosyidi & Haris, 2005). According to Siswono (2011) Creative thinking is the mental process which someone uses to come up with the "new" ideas as fluency and flexibility. In line with that, Nehe et al. (2017) stated that Creative thinking is a mental activity that is associated with sensitivity to the problem, consider the new information and ideas that are not usually with an open mind and can create relationships in solving problems. Ervync (1991) defines mathematical creative thinking as a person's ability to solve problems by developing thoughts that refer to the logical, didactic nature of knowledge and linking existing content in mathematics. According to Nurjannah (2016) the creative thinking process is a process to come up with new ideas, synthesize ideas as well as implement them. From what has been stated above, in this research, the creative thinking process is a thought process that produces new ideas or ideas and provides a different point of view in solving a particular problem.

Haylock (1997) suggests that the criteria for measuring creative thinking ability according to the Torrance Tests of Creative Thinking (TTCT), namely (1) Fluency, meaning the ability to provide many responses (responses) that are acceptable or appropriate; (2) Flexibility, meaning the ability to provide many types (methods used) in providing different responses; (3) Originality, meaning the ability to provide responses (responses) that are different from others. Silver (1997) says that "three key components of creativity assessed by the TTCT are fluency, flexibility, and novelty; fluency refers to

the number of ideas generated in response to a prompt; flexibility to apparent shifts in approaches taken when generating in response to a prompt; novelty to the originality of the idea generated in response to a prompt". In line with that, Siswono (2007) stated that the components of creative thinking include fluency, flexibility, and novelty. It can be concluded that the criteria in measuring creative thinking ability are fluency, flexibility, and novelty.

In the creative thinking process itself has stages, as stated by Torrance (1974) who describes the creative thinking process consists of: 1) recognize the existence of problems, information gaps, missing elements, 2) understand the problem, 3) make conjectures and formulate hypotheses, 4) test hypotheses and evaluate; 5) communicate the results. Meanwhile, Krulik & Rudnick (1999) suggested the creative thinking process, namely: synthesizing ideas, building (generting) ideas, and applying these ideas. ". According to Deporter and Hernacki (2015) the creative thinking process has 5 stages including: the preparation stage, which is the stage of identifying problems, goals, and challenges; the incubation stage, which is digesting the facts and processing them in the mind; the illumination stage, which is pressing to the surface; the verification stage, which is confirming whether the solution really solves the problem; the application stage, which is taking steps to follow up on the solution. Krathwohl and Anderson (2002) in Bloom's Taxonomy summarize the cognitive process domain of the creating aspect, namely building ideas (generating), planning, and producing solutions (producing). Siswono (2016) states that the creative thinking process is the steps of creative thinking which include synthesizing ideas, building ideas, then planning the application of ideas and applying these ideas to produce a "new" product. So in this research, the steps of the creative thinking process include: (1) understand the problem, (2) synthesize ideas, (3) build ideas, (4) design solution ideas, (5) apply solution ideas and produce solutions.

In solving math problems, it will indirectly train students' thinking, reasoning, logic, analysis, and abstract thinking. Abstraction ability is the ability of students to describe and imagine objects that physically do not always exist, which means that they do not exist in concrete or real form, they can only be imagined in the mind. This ability is used by students to visualize and manipulate virtual objects (Nurhikmayati, 2017). Mujis and Reylonds (2008) explained that the specific difficulty of mathematical knowledge for students lies in its abstract nature. Mathematics is said to be abstract because objects or symbols in mathematics do not exist in real life. With this, when students are given math problems that are abstract, it can also be seen how students' creative thinking processes in solving math problems. For this reason, media is needed that can help students visualize the abstract objects of these mathematical problems. Various research results show that the most effective learning media used to achieve the quality of education in entering the current era of globalization is to use information and communication technology (ICT) (Rusmana, 2015). In line with that, Rambung's research (2023) elaborated that the use of digital technology is one of the competencies prioritized in the independent curriculum. Because in this digital era, it is important for students to develop the ability to adapt to technology. The utilization of technology in education will be able to improve students' abilities and skills, one of which is the use of ICT-based media. The use of ICT-based media is considered more effective and efficient to assist student practice in solving math problems rather than just doing problems on paper.

ICT-based media is needed to display the visual form of abstract objects. ICT-based media allows students to construct and manipulate abstract objects with their way of thinking. One of the ICT media that is able to visualize abstract mathematical objects in the form of images or animations is GeoGebra. GeoGebra is a computer program that has a function as a tool for visualizing mathematical concepts that are useful as media in learning (Syahbana, 2016). In the process of solving math problems, the use of GeoGebra is an aid for students in solving abstract problems because the use of visualization of the problem at hand provides a real picture so that it helps students understand the problem. In terms of using GeoGebra itself, it provides benefits in the form of convenience for students in constructing and manipulating abstract math problems. In addition, using GeoGebra is quite simple, easy to access, and

provides many free features. The use of GeoGebra is very useful as a medium of assistance for students, especially in learning mathematics. According to Priatna & Arsani (2019), the benefits of using GeoGebra can be used to solve problems or verify mathematical problems as well as for mathematical exploration and discovery. In this research will be seen the creative thinking process that students will use from the way students solve math problems with GeoGebra.

Method

This research is a type of qualitative descriptive research. The data source in this research is descriptive data based on the results of practical tests and interviews from students. The research subjects were taken using purposive sampling. Based on Lenaini (2021), purposive sampling is a non-random sampling method where researchers ensure the quotation of illustrations through the method of determining special identities that match the research objectives so that they are expected to respond to research cases. Subject sampling is done by considering students who are considered suitable, namely students are expected to be able to work on the problems given and have been able to use GeoGebra. The subject selection was taken 3 students from grade 6 to solve math problems assisted by GeoGebra.

Data collection techniques in this research include: (a) Practical tests, students will be given math problems that they will work on with the help of GeoGebra, (b) Interviews, students from each category will be taken and interviewed to find out how students' creative thinking processes in solving math problems and the obstacles they experience in the creative thinking process while working on the problems given. This interview is assisted by a video recorder on a cellphone to make it easier to analyze the interview results.

The main instrument in this research is the researcher himself. The auxiliary instruments were validated math problems and interview guidelines. The research procedure used by researcher in this, first is that researcher look for students who are considered suitable for this research. then the researcher asks students to solve the spatial math problem by finding the volume and surface area of the cuboid using Geogebra. The math problems used in this research are as follows: (1) Determine the volume of a cuboid with length 60cm, width 40cm, and height 30cm!; (2) If you are going to make a glass aquarium in the shape of a cuboid with the size as above, how much glass area do you need? The selected subjects will work on the same problem and then an interview will be conducted regarding the student's process in solving the math problem.

The analysis used is data reduction, data presentation and conclusion drawing. Data reduction is done by selecting important and key things from test results and interviews with students in the process of solving math problems with GeoGebra. From the selected data, data presentation will be carried out from the description and analysis of the results of tests and student interviews in each category which will then be drawn conclusions.

Result and Discussion

In this research, the stages of the creative thinking process include: (1) Understanding the problem, i.e. students can understand the meaning of the given problem and know what to do with the problem; (2) Synthesizing ideas, i.e. students collect information or remember and combine ideas sourced from previous experience; (3) Building ideas, i.e. coming up with ideas related to the problem; (4) Designing a solution idea, i.e. students determine the idea used to solve the problem and run the application; (5) Applying the solution idea and producing a solution, i.e. implementing the idea to solve the problem and find the result.

The research was conducted at SDN Sumberagung, by taking subjects from grade 6 students. Before data collection, subjects were introduced and trained to use Geogebra. The subjects consisted of 3 students who were labeled S1, S2, and S3. As for the researcher himself labeled with P. Given 2

problems of building space and students are asked to solve the problem with the help of Geogebra. The results of the solution in Geogebra obtained from students are almost the same, as follows:

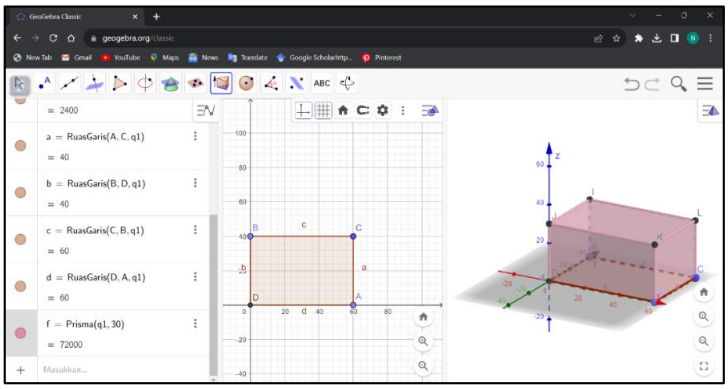

Figure 1. Student's results in finding the volume of a cuboid

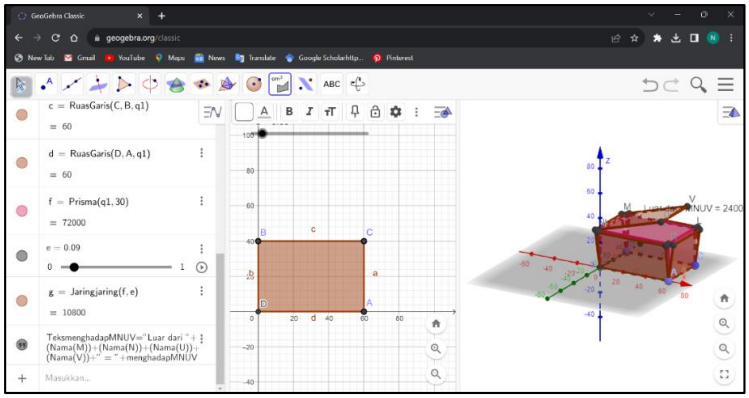

Figure 2. Student's result of finding the area of aquarium glass

S1 interview result

P : What do you think the two questions mean?
S1 : Problem number 1 is asked to find the volume of the cuboid, if problem number 2 might be looking for the surface area.
P : How do you find the volume?
S1 : Follow the formula
P : Do you still remember the formula for finding the volume of a cuboid?
S1 : Hmm... yes, the formula is p×l×t
P : How about finding the volume of a cuboid with the help of this application?
S1 : Hmm... still don't understand kak
P : Yesterday I showed you how to find a cube, do you still remember?
S1 : Yes, make the cuboid and then there is the volume.
P : Let me guide you to make it, what is known to make the cuboid?
S1 : There are length, width, and height
(builds the cuboid guided by the researcher)
P : So, what is the volume of the cuboid?
S1 : Here is 72,000 cm3
P : How do you find the glass area needed for the aquarium?
S1 : I don't know, it's hard
P : How do you usually do it?

S1 : Use the surface area formula
P : What is the formula?
S1 : Forgot, it's hard

Based on the results of S1's work and interviews, it can be seen that S1 can work on the problems given but is still not fluent in the operation of the Geogebra application. When given a problem related to the volume and surface area of the cuboid, S1 can already understand the problem in the problem. Then at the stage of synthesizing ideas, S1 immediately tries to recall the cuboid volume formula previously learned, but is still hesitant to work on problem number 2 and has difficulty remembering the cuboid surface area formula in the second problem. When looking for geogebra-assisted volume, S1 also still looks hesitant so researchers provoke students to recall. Furthermore, at the idea building stage, S1 looks for volume by making the cuboid first to visualize it, guided by the researcher. At the planning stage of applying ideas, S1 makes cuboids by arranging them from the known aspects of length, width and height. Finally, at the stage of applying the idea S1 makes the cuboid and can find the volume. From the interview, S1 shows the criteria for creative thinking, namely fluency, when students can understand the meaning of the given problem. Flexibility, which is when students remember the cuboid formula. However, students still cannot come up with novelty.

S2 interview result

P : Tell me what the two questions mean?
S2 : I think this is looking for the volume of the first problem, the second is looking for the area of the aquarium glass, which means the sides of the aquarium.
P : How do you usually find the volume of a cuboid?
S2 : Maybe multiply all of them
P : Why multiply all?
S2 : The cube is multiplied by all
P : Then, show me how you find the volume first.
S2 : Make a cuboid here (Geogebra) like what you taught before, then the volume will immediately appear.
P : How do you make the cuboids? Do you still remember?
S2 : Here, the base is made first and then built into a cuboid through the 3D option.
P : From the question, which one is the base?
S2 : Yes, it can be any
(making a cuboid without the help of the researcher)
P : So what is the volume of the cuboid?
S2 : 72,000 cm3

Based on the results of S2's work and interviews, it can be seen that S2 can work on the problems given with the help of the Geogebra application. When given a problem related to the volume and surface area of the cuboid, S2 can already understand the problem in the problem. Then at the stage of synthesizing ideas, S2 directly relates it to the formula, but has a little difficulty remembering the cuboid volume formula, so he assumes to multiply all known sides by analogizing it to the volume of a cube. This can lead to misconceptions when given more complex types of problems. S2 also had difficulty remembering the formula for the surface area of the cuboid in the second problem. S2 tends to remember how to use geogebra to determine the volume. In designing the application of ideas, S2 remembers the steps of using the application by making the base first to build a cuboid, assuming that all sides of the cuboid can be used as the base of the cuboid. Finally, at the stage of applying the idea, S2 succeeded in making the cuboid and was able to find its volume. From the interview, S2 showed creative thinking criteria, namely fluency, when students can understand the meaning of the given problem. Flexibility,

namely when students try to find volume with the help of geogebra. However, students still cannot bring up novelty.

S3 interview result

P : Try to explain the meaning of the two questions!
S3 : Hmm, I think in question number 1 was told to find the volume of the cuboid and in question number 2 to find the surface area.
P : Then how do you find the volume of the cuboid?
S3 : Usually I use the formula p×l×t
P : How do you find the volume using geogebra?
S1 : Build the cuboid first and then the volume will appear using this
(making the cuboid without the help of the researcher)
P : For question number 2, why do you think it's looking for the surface area?
S1 : Because finding the area of the aquarium glass means the area of all sides of the aquarium. The area of all sides is the same as the surface area
P : Then how do you find the area of glass needed to make an aquarium?
S3 : Yes... find the surface area
P : Still remember the surface area of the cuboid?
S3 : I don't remember the formula but usually I add all the area of the sides of the cuboid
P : How do you determine the surface area of the cuboid?
S3 : Make the nets like this (using the "Net" feature on geogebra), the surface area immediately appears
P : So how much is the glass area?
S3 : Because aquariums usually don't have lids so the surface area was reduced by the area of the top side of the cuboid
P : What is the area of the top side?
S3 : 2,400 cm3 (using the "Area" feature in geogebra to find out the specific area of the top side)
P : So what is the area of the aquarium glass?
S3 : 10,800 minus 2,400 so 8,400 cm3

Based on the results of S3's work and interviews, it can be seen that S3 can work on the problems given with the help of the geogebra application. When given a problem related to the volume and surface area of the cuboid, S3 can already understand the problem in the problem. Then at the stage of synthesizing ideas, S3 immediately remembers the formula and can remember the cuboid volume formula, but does not remember the surface area formula. On the other hand, S3 looks for the surface area by analogizing the cuboid formula by adding up all its sides. S3 also remembers the use of geogebra that has been taught before to find the surface area. Furthermore, at the stage of building ideas to find the surface area, S3 makes the cuboid to find the area of the sides. Here, S3 argues that the cuboid nets are the surface area. In the design of applying ideas to find the required glass area, S3 believes that the aquarium does not have a lid so S3 will subtract the lid area from the total surface area. Finally, at the stage of applying the idea S3 made a cuboid net and managed to find the surface area and then subtracted it from the side area of the aquarium lid to get the glass area of 8,400 cm3. From the interview, S3 shows very creative thinking criteria, namely fluency, when students can understand the meaning of the given problem. Flexibility, namely when students try to find the surface area with the help of geogebra. Novelty, students experience obstacles to remembering the formula for the surface of the cuboid, students use another way by adding up all the sides that make up the cuboid.

The results of the interview showed that in the creative thinking process students in solving mathematical problems assisted by Geogebra experienced obstacles at the stage of synthesizing ideas. In line with Tilaar (2012) who states that at this stage there is a deadlock that causes frustration. Airasan states that the creative thinking process generally coordinates with learning experiences (Siswono, 2008). Judging from the responses of S1, S2 and S3 who immediately tried to remember the formula when given a math problem. This can be caused by the learning experience that is more dominant by memorizing formulas. In line with that, mathematics learning is generally still dominated by the introduction of formulas and concepts verbally, without sufficient attention to student understanding (Munandar, 1999). With this, students who find it difficult to remember all the mathematical concepts learned in previous classes will also have difficulty solving math problems. Likewise, when starting to work on problems with Geogebra assistance, students recall how to use it from previous learning experiences. It can be seen from S2's statement, making cuboids here (Geogebra) as you taught before, the volume will immediately appear, which means that students use geogebra by remembering it from previous experiences. In addition to learning experience, the ability to process known knowledge also influences the creative process (Siswono, 2008). Judging from S3's statement when remembering how to find the surface area, he did not fully rely on the formula but analogized by adding all sides of the cuboid. He said that he don't remember the formula but he usually add all the area of the sides of the cuboid. This can be one of the focuses to be able to improve students' creative thinking skills. According to Siswono (2008) said that to develop creativity, students can train to find analogies.

Conclusion

The results of this research show the creative thinking process of students in solving mathematics problems based on the stages of the creative thinking process which includes understanding the problem, synthesizing ideas, building ideas, designing solution ideas, and applying solution ideas and producing solutions. At the stage of understanding the problem, S1, S2 and S3 have been able to understand the meaning of the problem given and know what to do with the problem, namely to find the volume of the building and the surface area of the cuboid. At the stage of synthesizing ideas, S1 can remember the cuboid volume formula previously learned in class, but experienced obstacles in working on problems in Geogebra. S2 also experienced obstacles in remembering the surface area formula but could be overcome by utilizing geogebra to determine the surface area. S3 also faces the same obstacle, namely difficulty remembering the surface area formula but in manual work, he overcomes it by adding up all sides and can find the surface area of the cuboid with the help of geogebra. At the idea building stage, S1, S2 and S3 will make a cuboid first to visualize the cuboid. Furthermore, at the stage of designing the solution idea, by building the cuboids they will be able to know the volume and by utilizing the features on geogebra can also find out the surface area. Finally, at the stage of applying ideas they can find the volume of the cuboid and by using the "Net" feature S3 can find the area of the cuboid net that has been made, where the net area is the surface area of the cuboid. From the above results, it can be concluded that in the creative thinking process of students the obstacles that most often occur are at the stage of synthesizing ideas.

Suggestions from researchers based on the conclusions that have been obtained are in improving students' creative thinking skills that must be done is more focused on the development of students' abilities at the stage of synthesizing ideas. As well as the importance of ICT-based learning for students so that it can help students solve problems, especially abstract problems, and develop students' abilities in technological adaptation.

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