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Construction of Generating Objects in Mathematical Visualization:ACase Study of Male - Field Independent Student

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Abstract: *The purpose of this study is to describe how students construct in generating objects on mathematical visualization. The subject of this study was an independent high school male field student based on the GEFT test. The result shows that SLFI represents a 2D pool. SLFI imagines that therepresntative pool made is a form of swimming pool viewed from above. Thus, the visible side is only the surface of the pool. SLFI provides information on the size of the representation that have been made. The pool representation forms are divided into three parts, the first is for adult category pool, second part is for adolescent, and the third is as border part of both categories. While on the border part, it is divided into two parts, the higher side and the lower side. He develops the information existed in the task, such as the size of the barrier that was not previously known. Biside that, he correlates the shape of the pool with the 3D shape or applied geometry, like a beam. The beam shape describes the pool form for adult and adolescent category.Furthermore, he explores and recognizes the form of representation that has been made to his experience.*

Keywords: *Contruction, generation, mathematical visualization, male, field-independent*

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I. Introduction

Students' tendency in the process of solving math tasks still use the memorization system, especially adjusting the settlement procedures that have been obtained without understanding and connecting their knowledge. According to [1] states the process of solving mathematical tasks, students tend to memorize procedures and mathematical operations and use numbers and terms that become keywords. Besides, [2] reveals that students tend to solve the tasks without properly understanding the intent of the whole tasks, students tend to memorize during completion of the tasks, rather than connecting their knowledge to understand the task. Thus, one of the impact is that students have difficulty or error during solving math tasks.

[3] revealed that some students fail to solve a word from a task, as well as a lack of ability to imagine from the situations described in sentence of the task. Because students can not properly visualize the task, they are unable to choose the correct way to solve math task. Besides, [4] found that students were more systematic and effective in solving tasks by using various representations. Information to be learned in the classroom should be consistent and explicitly conveyed to the student in various ways so that students can develop various methods and thinking techniques to improve the cognitive structure. What students faced in solving math task is that students will be more difficult to interpret the image presented in the task.

The process of completing the task can not be separated from how the way to explore the task. According to [5] visualization is a powerful tool in exploring mathematical tasks and for giving meaning to mathematical concepts and relationships. Some researchers have reviewed visualization. [6] [7] [8] [9] Yet still rarely find a mathematical visualization research in mathematics education, as it tends to be more research in visualization model and technique.

Referring to the problems above, visualization can be considered as an important aspect in mathematics. In defining visualization, [10] states that visualization is a cognitive process or an action whereby an individual improves the connection between an internal construct and something accessing through the senses. A connection can be made from both ways. An act of visualization can be from the mental construction of an object or process, in which an individual will associate with objects or events received by him externally. Visualization is also defined as the process of transforming information into a form of perception so that the result described appear by linking existing data [11]. In addition, visualization is the process of using geometric illustrations on mathematical concepts. Visualization is the most common technique used in mathematics learning [12].

Furthermore, visualization is also the process of formating an image by an action in which an individual person forms a strong relationship between the mind and something accessed through the senses [13].

In this study, visualization is a cognitive process to manipulate and explore images as a result of the creations and interpretations of the mind during completing the tasks include aspects of generating, inspecting, transforming and evaluating [14].

Dealing with the definition of visualization [3]; [11]; and [14], the cognitive process has a significant role especially during the process of solving math tasks. Each student certainly has a different cognitive process with other students. It resulted an assumption that the visualization of the students are also different. Regarding the cognitive differences of students certainly can not be separated from the cognitive style.

The cognitive style refers to one's characteristics and consistency in responding, remembering, organizing, processing, thinking and problem-solving. Cognitive style in this study includes cognitive style of field independent and field dependent. The dimensions of cognitive style of field independent and field dependent have been studied by researchers, especially those related to the mathematics learning process. [15] examined the cognitive styles of mathematical learning, [16] examined the relationship of cognitive style of field independent and field dependent with the method of teaching in mathematics learning process.

According to Within and Goodenough, someone who has an independent field cognitive style can bring back the information from his own memory. He tends to use the problem-solving approach in a more analytic way. While someone who has a field dependent cognitive style is difficult to bring back the information from memory, and use a more global approach to problems. In this study, the mathematical visualization process is associated with independent field cognitive style.

In addition to differences in cognitive styles, gender is also likely to affect a person's cognitive processes in solving math tasks. According to [17] developed a theoretical framework to explain the study of differences between women and men in processing information. The differences of gender issues in an information process is based on different approaches that men and women use core information process to solve tasks. Men generally solve the tasks do not use all the information which is available, and also do not process the whole information so that it can be said that men tend to do information process restrictively. Women are seen as more detailed information processors, who process information on most of the information core. With regard to the process of mathematical visualization, gender has a significant role especially in processing information. Researchers suspect female students have a tendency to show creation and manipulation during receiving information, because the visualization process can not be separated from the process of manipulation.

Based on the background above, researchers are being inspired to describe the construct of generating objects on the mathematical visualization of male students field independet with independent field cognitive style in solving the problem

II. method

The research design was descriptive explorative with qualitative approach. The data collection and data analysis was based on[18]. The subjects of the research were the Junior High School students, where the male had *field-independent cognitive style.* The subjects were chosen by using purposive sampling based on the answers which showed all of the mathematical visualization aspects.

The instruments used in this research were:

1. Giving GEFT test (*Group Embedded Figures Test*)
2. The mathematics question sheet was shown in picture 1 as the following:

> A swimming pool with length 50 meters and width 25 meters which the depth was differentiated into two categories, namely adult and teenager category. The adult category was 3 meters and the teenager category was in depth in 26 meters and teenager category was in depth in 2 meters with the length of 20 meters, while the basic border of the two categories was made in slope. How much liters of water needed to fulfill the swimming pool? Explain your answer!

Figure 1. Instrument of Question Sheet

The procedure of data collection was aimed to explore the mathematical visualization process in solving contextual task, started by giving cognitive style test to 25 male subjects. Then, 14male subjects who had field independent were given mathematical visualization test. The researcher conducted the interview deeply based on mathematical visualization aspect referred to the result. Credibility of the data used time triangulation. The data analysis referred to the mathematical visualization aspect through the steps namely data categorizing data, reducing data, presenting the data, and making conclusion related to the mathematical visualization aspect in the process of solving the task.

III. Result

The SLFI written answer regarding the aspect of generating objects on TVK is shown in Figure 1following.

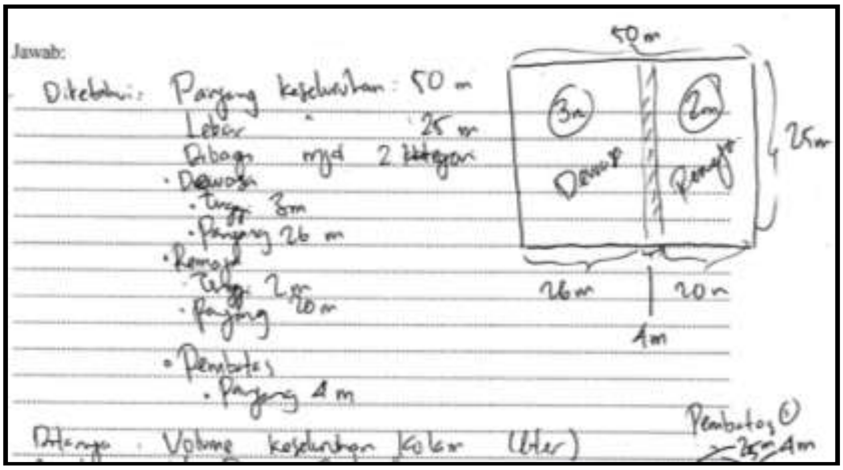

Figure 1. Written Answer of SLFI Related to Generating Objects on TVK

Interview sample between researchers and SLFI relating to aspects of generating objects on TVK are presented in Table 1 below.

Table 1.
Interview sample of TVK on Aspects of Generating Objects by SLFI

Researcher	:	Ok, Could you please explain this answer?
Subject	:	*(The subject read aloud the information from the task for 7 seconds)* it is known that
		the pool is 50 m long overall and 25 m wide, then there is an adult pool with depth or
Researcher		height 3 m and length 26 m and adolescent pool with height or depth 2 m length 20
Subject	:	m and barrier
	:	Cound you explain your picture here? *(while addressing the picture)*
Researcher		The picture shows that the overall length is 50 m, and the overall width is 25 m, the
Subject		number in this circle indicates the depth of adult and adolescent, the 4 m long barrier,
Researcher	:	the adult pool is 26 m in length, the adolescent pool is 20m long.
Subject	:	So, why do you draw your picture like this?
Researcher	:	It is more understandable.
Subject	:	What does it mean?
	:	It is more visible
Researcher	:	What is the more visible part?
Subject		The overall length of the pond, the length of the adult pool itself, the length of the
Researcher	:	teen pool itself, then the depth one by one.
Subject	:	Could you explain more?
	:	I imagine this picture being seen from the above.
Researcher	:	So, how is the shape?
Subject		If I look from above it is rectangular, but if the adult and adolesblocjcent pool is a
	:	beam shape, there are a triangle, prism and beam.
Researcher	:	Why is there a rectangular shape?
Subject	:	Because I see it from above, so like a rectangle, it's like a rectangular side because
Researcher	:	the length of the pool is not the same as the width of the pond
Subject	:	What is a rectangle?
Researcher	:	Overall pool surface
	:	Based on this picture, which one is the shape of the beam?
	:	This one and this one *(he points to the picture, more precisely at the adult pool and*
	:	*teen pool)* but overall it is not a beam because there is a slope or a slant
Subject		Why is there a beam shape?
		Actually this is not a beam, but this building is a beam *(refers to the adult category*
Researcher	:	*pool)* because it has a different ribs and width and there is height that was the depth
Subject	:	of which belongs to adult and adolescent pool
	:	How is the border part?

Researcher	:	It's also a beam but on the top one, then the bottom one is a triangular prism because
Subject	:	there is a sloping part, then when it is viewed from the side like a triangle
Researcher	:	And then, what does it mean? *(the researcher was asking about the picture)*
Subject	:	It is the border part of adult and adolescent pool
Researcher	:	Why it is made such as this picture?
Subject	:	It is different *(while smilling)*
Researcher	:	What is the difference?
Subject		Because there is a slope, so I give shading
	:	Yeah you said that in the barrier on triangle, prism and beam, that means how?
Researcher	:	on the barrier, I imagine there are 2 forms, the shape of the beam is top then the
Subject	:	triangle's prism is underneath
Researcher	:	Then you said there is a triangle, which part is that mean?
Subject	:	On the prims side, triangular prism
		Why it is triangular prism?
Researcher	:	If I look from the side of the triangular shape, so I conclude it is a triangular prism
Subject	:	I got it
Researcher	:	Before this final, what material do you get?
Subject		Geometry
		What geometry material?
		There are rectangle, triangular prism and beam

The process of representing data information performed by SLFI imagined on the viewing the pool side from above to make it easier to describe swimming pool, so SLFI created a 2-dimensional form that reprensents the shape of a swimming pool. The first is SLFI creates a horizontal line about the length of the pool, then creates a vertical line that represents the width of the pool. Next divide it into 2 parts which states the pool is divided into 2 categories, namely adult category and adolescent category. The process of dividing the pool produces a different shape, it is based on the length of each category. SLFI characterizes the depth of each pool category written in the section of each category. To more easily identify the depth size of each pool category, SLFI gives a mark.

The process of developing data which is done by SLFI provides signs to make it easier in recognizing the size, such as a curly bracket representing the length and width of the pool, a line mark representing the size of the border part between the two pool categories, a shading mark or the word "LIMITATION" to state the boundary area between the two categories. Next declare the length of each pool category. In addition, the subject also determines the size of the delimiters of both pool categories. SLFI gets the length of the boundaries of the two categories of results looking for a grid between the overall length and the length of each category. SLFI writes the information asked in the question, even without giving a description of the question.

To know the other geometric shapes, SLFI does a partition of the pool, thus obtaining multiple builds such as the first beam build which represents an adult pool, a second beam representing a teen category pool, a third beam representing a barrier pool between the two categories higher, and build a triangular prism that represents the lower divider pool.

The form of the beam obtained by SLFI is by looking at the pool in each part of the pool. The first part describes the adult category pool, the second part describes the youth category pool and the third part describes the pool between the two categories, where the border of the two pools is partitioned into the higher (beam) and the lower (triangular prism). The shape of the beam obtained by SLFI refers to the size of the different ribs, where the size of the long ribs, width and height of each pond. SLFI considers that the depth of each pool of adult and adolescent categories is the height of the building beam. So it can be said that SLFI compares between the form of rectangle with the beam through its characteristics and point of view. And it can be seen that SLFI connects between the form of rectangle and the beam, in which the rectangular shape representing the pool viewed from above is the surface of the beam from the pool.

The aspect of generating objects done by RFI subjects in completing TVK is presented in Figure 2 below.

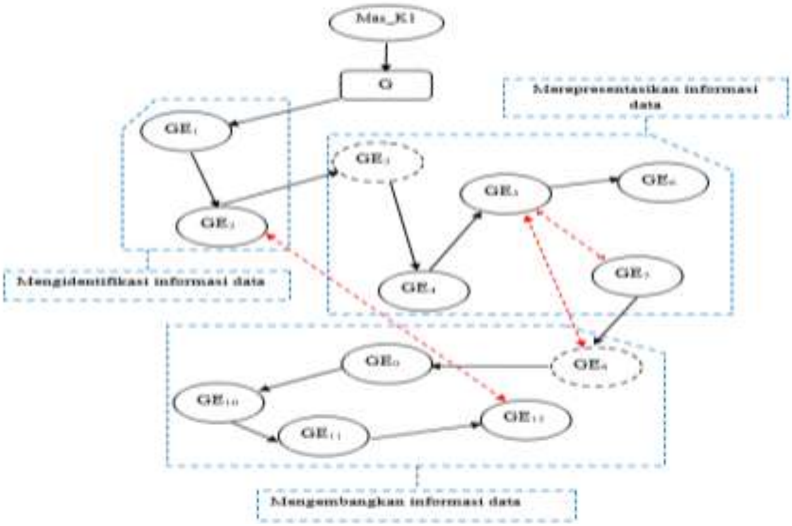

Figure 2. RFI Subject Flow Diagram in exploration activities on TVK

Information:

Mark	Mark Explanation
Mas_K	Reading about visualization question test for contextual questions
G	Regenerating the contextual questions presented
GE_1	Mentioning the pool element sizes, such as overall length and width, adult pool size, length of adolescent pool, and what is asked in question
GE_2	Providing information of overall length = 50 m, overall width = 25 m, 2 pool category, adult length = 30 m, adult height = 3 m, adolescent length = 17 m, adolescent height = 1.5 m, limiter length = 3 m, and "asked: liters of water needed to meet the pond"
GE_3	Imagining the shape of the pool made based on the position of the point of view
GE_4	Determining the position of **"above side"** to make it easier to understand the created image
GE_5	Creating a visual form in 2-dimension (2D) to make it easier to represent the shape of the pool
GE_6	Dividing the pool into 2 parts, the first part shows the adult category, and the second part shows the category of adolescents
GE_7	Providing additional information to clarify the form of representation that has been made, such as the word "adult" to show the adult category pool, and the word "adolescent" to show the adolescent pool category
GE_8	Differentiating the depth of the two categories of pools with a given **circle** on each size
GE_9	Giving a sign to clarify the image, such as **curly braces** showing the length and width of the pool
GE_{10}	Giving a **line mark** indicating the size of the divider between the two pool categories
GE_{11}	Provide information **"LIMITATION**" or **"shading"** to specify the boundary area between the two pool categories
GE_{12}	determine the length of the divider by finding **the difference** between the overall length and the length of each pool category

The process of representing the data information performed by the LFI subject **imagines** looking at the pool from **above side** to make it easier in describing the pool. Thus, the LFI subject creates a **2-**dimensional form about the shape of the pool. In addition to the 2-dimensional form, the LFI subject also imagines a **3-dimensional pool shape**. The first is that the LFI subject creates a horizontal line which represents the length of the pool, then creates a vertical line that represents the width of the pool. Next divide it into 2 parts which is divided into 2 categories, namely adult category and adolescent category. The process of dividing the pool produces a different shape, it is based on the length of each category. The LFI subject writes the characterizes of the depth of each pool category. To more easily identify the depth size of each pool category, the LFI subject gives a mark. So in the process of representing contextual problems LFI subject tend to imagine the form of swimming pool either 2-dimensional or 3-dimensional.

In the process of categorizing the data conducted by the subject of LFI is to focus on the position and element. First, the subject recognizes some geometry based on position. Rectangles is based on the depiction of the pool viewed from above. The reason of the LFI subject states as the rectangle is the different side size, where the actual length of the pool differs from the actual width of the pool. So the subject of LFI assumes that the surface of the pool can be represented as a rectangle. To find out other geometric shapes, LFI subjects do partition the pool, thus obtaining multiple solid geometry such as the first beam that represents an adult pool, a second beam representing a adolescent category pool, a third beam representing a border pool between the two categories the upper part, and build a triangular prism that represents the lower pool. So it can be concluded that the subject of LFI categorizing data on TVK focus on the point of view of the characteristics of the solid geometry object.

IV. Conclusion

SLFI represents a 2D pool. SLFI imagines that the pool is a form of swimming pool viewed from above, so that only visible surface of the pool. SLFI provides information on the size of the representations that have been made. Pool forms are divided into three parts, the first part is for adult category pool, second part is for adolescent, and the third part is as border part of both categories. While on the border part, he divides into two parts, namely the higher and the lower. He develops the information that exists in the task, such as the size of the border that was not previously known. In addition, he correlated the shape of a pool with a 3D shape or solid geometry space, like a beam. Beam is to describe the pool for adult and adolescent category. He can not identify the name of the boundary, but he can know the limiting form because of his knowledge. In addition, he explores and recognizes the form of representation that has been tailored to the experience he has acquired, so he describes the imagination in mind.

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