Visualizer’s representation in functions

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Abstract. Students’ understanding of a mathematics objects can be seen by their perspective of a mathematics topic. In other words, the study of a specific case can enrich one’s conceptualization of the general. This study is a descriptive qualitative research. The visualizer’s paperwork is described based on their preference in representing a function. Visualizer’s paperwork and interviews provide opportunities to get additional description about her mathematical conceptions and how her understanding about functions by using representation. Visualizer tends to connect their imagination of a picture and represents it based on her ideas. Visualizer defines functions by its perceptual unit that each elements of the domain connected with exactly one element of the codomain. In modelling graph representation, object imager uses all information in the diagram and represent it in symbol notation. In interpreting functions, object imager prefers diagram representation rather than word situation and symbol representation.

1. Introduction
Some people are prefer at processing words and some people are prefer at processing pictures. Most studies have investigated individual preferences based on visual dan verbal information since 1970s partly due to its difficulties in conceptualizing and measuring the underlying both visualizer and verbalizer cognitive style [1–3]. However, considerable cognitive and neuroscience research conducted by Levine [4] gives a new perspective that imagery is unitary. Blajenkova [5] stated that there are two types of imagery in visualizer cognitive styles. Both of them are object and spatial imagers that encode and process visual information in different ways. A perspective of an object is related to the representations of the appearances of an objects in terms of their form, size, shape, colour and brightness. Besides, spatial imagery is related to the abstract representations of the spatial relations amongst objects, parts of objects, locations of objects in space, movements of the objects and the object parts and other complex spatial transformations [6]. This study visualizer subject is seen as the object imagery. The representation of the subject is seen by her understanding about a topic in mathematics.

Visualizer’s understanding of a mathematics objects can be seen by their perspective of a mathematics topic. Considering visualizers’s thinking about a mathematical topic, allows one better understand the broader domain of visualizers’s mathematical thinking and its influence on teaching and learning process. Previous studies conducted by Setyawan [7] investigate that students’ representation of a mathematical topic contributed significantly to their conceptual understanding of a linear equation in one variable (LEOV). In other words, the representation about a mathematical topic can be used to construct the understanding of the visualizer subject. Representation of the teacher will
affect the students' understanding about a concept and will be a representation of the students has learned. The student's representation can be visual, verbal, and mathematical. This process will continue to be modified in the mind of the student [8].

Most studies has focused on how representations benefit students’ understanding about a topic in mathematics [8, 10, 11]. Functions, as one of topics in mathematics, can be seen in picture, words and symbol representations. Within this literature, there is some aspects of the functions concept are most crucial for deep understanding. This present study identify how visualizer subject defines functions as the relation between domain and codomain, gives examples and non-examples of functions, interprets functions by using three kinds of representation such as diagram, situation description, and symbols representation.

This study was designed to get greater depth of information concerning visualizer’s understanding about functions. It is describing visualizers’s perspective, especially object imager, in defining functions using their own beliefs, giving examples and non-examples of functions, and interpreting functions represent by diagram, situation description, and symbols.

2. Method
This case study, a part of a larger qualitative study on investigating cognitive style’s representation, aims to validate visualizer’s understanding related to functions when dealing with diagram, situation description and symbol representations. The visualizer’s paperwork is described based on her definition about functions, examples which is written and preference in representing a function. The visualizer subject is a 3rd-year college student of Universitas Ahmad Dahlan.

By using a diagram, situation description, and symbols representation, the subject explains her understanding and perspective about functions. The information about conceptions of visualizer’s representation in functions was obtained during the first 3 weeks of study, using a written instrument and two interviews. Visualizer’s paper work and interviews provide opportunities to get additional insight concerning her mathematical conceptions and perspective influenced those conceptions.

Table 1. Visualizer’s tasks on representing functions

| No  | Visualizers tasks                                      | Representation                  |
|-----|--------------------------------------------------------|--------------------------------|
| 1.  | Define functions by using own word                     | Word representation            |
| 2.  | Give example and non-example of functions              | Symbol representation          |
| 3.  | Choose appropriate representation to make best use in defining functions | Subject’s preference in representation |

3. Result and discussion
Table 2 summarize visualizer’s paperwork in representing the functions. For example, visualizer’s perspective about function is seen by using diagram representation. This study found that visualizer’s word representation about functions is described based on the visualization of diagram representation. Most of the examples and non-examples is written using diagram.

Table 2. Visualizer representation in Functions

| No  | Visualizers tasks                                      | Representation                                      |
|-----|--------------------------------------------------------|-----------------------------------------------------|
| 1.  | Define functions by using own word                     | Connecting the elements of domain to exactly one elements of codomain |
| 2.  | Give example and non-example of functions              | Using diagram representation rather than both word and symbol representation |
| 3.  | Choose appropriate representation to make best use in defining functions | Subject’s preference in diagram representation |
For the task 1, visualizer defines functions by connecting the elements of the domain with exactly one element of the codomain. In the written instrument, visualizer tends to connect their imagination of a picture when she was in senior high school and represents it based on her ideas (Figure 1). For example, she was explained that all of the elements of the domain should have relations with the codomain. In addition, all the elements of the domain should have only one relation with the codomain. This explanation is confirmed by the interviews that she remembers the definition of functions based on her memory in Senior High School while her teacher explains the definition by using a diagram.

![Figure 1. Visualizer’s word representation about functions](image1)

For the task 2, visualizer gives examples of functions by using diagram and explains it by using her definition about the functions. It is interesting while she explains that the examples related to the linear equation or linear functions. Kozhevnikov [5] stated that the perspective of an object imager, visualizer subject, refers to representations of the appearances of an objects in terms of their precise form, size, shape, colour and brightness. By confirming her written work, the researcher found that she connecting its definition with linear equation because it has equals sign (=). It also found that the subject uses the diagram to represent the examples of functions and non-functions (Figure 2). Visualizer also mentions that one example of functions is linear and quadratics function from the interview.

![Figure 2. Visualizer’s word representation about functions](image2)

For task 3, visualizer prefers diagram representation rather than word situation and symbol representation (Figure 3). She thought that diagram representation was better in interpreting the definition of function concept than others. Her preference is relevant with the results of Kozhevnikov [6] whom found that object imagers encoded and processed the images holistically. They processed the images as a single perceptual unit. In comparison with the previous study [11, 12], diagram representation helps visualizer to understand the concept of function. Students’ representation is the result of its decision from a phenomenon which was experienced. Students’ representation of a concept is influenced by two factors such as internal factors and external factors. Internal factors is the level of student development that form mental model which is displayed through their representation of a concept [13]. Besides, external factors is adopted from the environment either directly or indirectly, qualitatively or quantitatively [13].
Figure 3. Visualizer’s preference in representation

Since representation of the teacher will also greatly affect the students' understanding and will be a representation of the concept he or she has learned. The visualizer understanding about function is described based on their explanation of functions by using multiple representation. The visualizer's representation can be visual, verbal, and mathematical. This process will continue to be modified in the mind of her [8]. In this study, diagram representation helps visualizer better than the other representation to construct the concept of function. Visualizer explained the similarity between word, diagram and symbol representation (Figure 4). She defines the domain and the codomain of the functions in both word and symbol representation. She connects the concept of function in word and symbol representation with the diagram representation.

Figure 4. Visualizer’s understanding of function using representation
Based on the data, the diagram representation helps visualizer to construct the understanding about functions. Several researchers agree that in mathematics education the term representation refers to the construction, abstraction, and demonstration of mathematical knowledge [9-11, 14-15]. Panasuk [10] stated that the students’ ability to create, recognize, interpret, make connection, and translate among representations are powerful communication tools for mathematical thinking. It is relevant with the data observed that representation helps the students to construct the understanding of a topic in mathematics [16]. Visualizer’s mathematical thinking in representing functions is related to an image as memory that she learned [15]. In this study, visualizer’s preference to describe the concept of functions is by using diagram representation. For object imager, the representation is refer to the literal appearances of a concept.

Since visualizer prefer using diagram representation to both word and symbol representation, the further study can describe and make comparison between object imagers and spatial imagers. The existence of two distinct visualizer learning styles is classified as object and spatial imagery. Both of them is seen as a subsystems that encode and process visual information in different ways [5].

4. Conclusion
For the conclusions, visualizer tends to connect their imagination of a picture and represents it based on her ideas. Visualizer defines functions by its perceptual unit that each element of the domain connected with exactly one element of the codomain. In interpreting functions, visualizer prefers diagram representation rather than word situation and symbol representation. Based on the data, diagram representation helps visualizer to construct the understanding about functions. Visualizer defines the functions from domain to codomain by connecting the elements of domain to exactly one elements of codomain. Visualizer’s preference is using diagram representation rather than both word and symbol representation. Furthermore, it is potential to compare the representation between two imagers, object and spatial imagers, above to confirm the findings and also the cognitive style understands among the other relevant studies.

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