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Embodied cognition of the student mathematical imaginations in conceptual understanding of algebraic expression

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Abstract. Development of imagination in education creates a continuous education process and always new. The aim of research to describe of the student mathematical imagination and embedied cognition in conseptual understanding of algebraic expression. Type of this research is explorative with qualitative descriptive approach. The study was conducted in SMP Negeri 2 Semarang, at the end of 2017 for 3 months. Subjects involved in the study is a student who has a visual learning style. Methods of data collection using tests, interviews and observations. Test of data validity of research result using time triangulation technique. The results of this study are as follows: 1) subject imagine variables as objects that she recognized, such as the number of objects in a box or tin; 2) subject imagines an example and not an example of algebraic expression when it will define the concept of algebraic expression; 3) subject using gesture representation of variables, coefficients or constants; gesture pointing and gestures of writing as embodied cognition of the mathematical imaginations used; 4) subjects using the utterance as embodied cognition of mathematical imagination used or as the embodiment of social interaction that he did to get a confirmation or approval of researchers.

1. Introduction

Imagination is the key to the development of science. An imaginative and creative thinking process becomes the opening way for the learning process. The development of imagination in the world of education, bringing novelty in the process of continuing education [1]. In 2008, a conference was attended by 140 delegates from 20 countries. This conference became the importance of the imagination to provide quality education for the students [2]. Imagination is often used in learning mathematics, especially about geometry. Arana did research on it and produced a statement that the legitimate curve is a curve that can be imagined and can be traced through a series of continuous motions [3].

Imagination is the thought process of forming a mental image that requires an embodiment in its disclosure. Embodied cognition from the imagination of mathematics can be seen from the actions of our bodies. Some researcher that became a reference is a study by Alibali & Nathan which states gestures as Embodied cognition from the imagination of mathematics [4]. In addition, we also refer to the results of research from Nemirovsky, Kelton, & Rhodehamel which states that Embodied cognition from the mathematical imagination can be seen from the multimodality used in the dialogue. This multimodality is called utterance [5]. From both studies, researchers used gestures and utterance as Embodied cognition from the imagination of mathematics. This is one of novelty value in this research considering that the

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topic of imagination is less interested in education researcher in Indonesia, especially in learning mathematics.

A preliminary research involving 4 subjects was conducted to find out their understanding of algebraic expression through their imagination. The results show that the lack of involvement of the imagination in the process of understanding the students so that there is a misunderstanding of the concept of variables as shown in Figure 1 below.

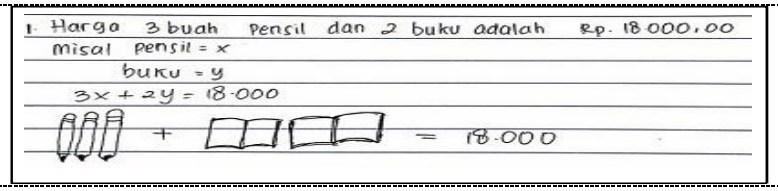

Figure 1. Preliminary research results

From Figure 1 it appears that the variable is defined as an object, whereas in this case the meaning of the variable is the unknown price of an object. Based on the description, the issues raised in this research are: "How to Embodied cognition from the students' mathematical imagination in understanding the concept of algebraic expression". So the purpose of this study is to see the quality of imagination and Embodied cognition of the students' mathematical imagination in understanding the concept of algebraic expression.

2. Experimental Method

The type of this research is explorative research with qualitative descriptive approach. The study was conducted in SMP Negeri 2 Semarang, at the end of 2017 for 3 months. The subject involved is a student who has a visual learning style. The selection is done based on the characteristics of data to be searched is about the imagination. The research instrument used in this study refers to the development of previously performed and validly tested instruments both in content and field trials [6]. Data obtained through test methods, interviews and observation. Testing data validity using time triangulation technique.

Procedure of research through the following stages: (1) provide the first test for conceptual understanding of algebraic expression (TPKBA1) on subject; (2) an interview to know students' conceptual understanding of algebraic expression and the quality of imagination used in conceptual understanding of algebraic expression; (3) observation of interview process to find out embodied cognition from students' mathematical imagination; (4) analyzing the results of interviews and observations of TPKBA1; (5) gives TPKBA2 on subject; (6) repeat the activities on points (2) and (3) based on TPKBA2 results; (7) analyzing the results of interviews and observations of TPKBA2; (8) data triangulation by comparing the analysis of interview result and observation of TPKBA1 and TPKBA2; (9) concludes if the data is valid, and performs TPKBA3 if not yet valid. Repeatable process until it gets consistent data.

3. Result and Discussion

3.1. Result

Embodied cognition of the students' imagination in conceptual understanding of algebraic expression is described based on the 7 stages of cognitive level in the cognitive understanding of the proposed understanding of Bloom [7], among others: (1) change 2 cans of candy and 5 candies into 2x + 5; (2) exemplify 3x + 6 with imagination pak Budi bought 3 packs of books and 6 books; (3) classify 3p + 2 in algebraic expression and 2a + 4 = 8 in non-algebraic expression; (4) summarizes the characteristics of the algebraic expression is that there are constants, coefficients, and variables; (5) summarize the meaning of algebraic expression is a matter of mathematics that contain constants, coefficients and variables and variables are not yet known; (6) compares algebraic expression with non-algebraic expression, ie if it is not an algebraic expression there is no variable; and (7) explains the reason for

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algebraic classification changes from x2 + xy + 4x + 5y - 5 to (x + 5) (x + y - 1), where the classification of new expression remains algebraic because there are variables, constants, coefficients. And describes the algebraic classification of algebraic expression from x2 + xy + 4x + 5y - 5 to x2 + xy + 4x + 5y = 5, which is changed into not algebraic expression because it is an equation form.

Embodied cognition of mathematical imagination that the subject used in conceptual understanding of algebraic expression is gesture, which consists of: (1) the gesture of a tin representation that leads to the representation of variables; (2) gesture representation of the book pack leading to the representation of variables; 3) gesture representation of coefficients embodied with numerical representation movements; (4) gesture after the representation of variables formed or quantity of gesture of variable representation performed; (5) writing gestures in the form of writing movements in the air and writing movements on paper; (6) gesture pointing in the form of motion pointing at the writing or pointing in the air. As for some examples of gestures can be seen in Figure 2, Figure 3 and Figure 4.

Figure 2. Representational gestures

Figure 3. Writing gestures

Figure 4. Pointing gestures

Figure 2 shows the subject performing an upward motion lowered the hand parallel to form a box referring to a variable representation. Figure 3 shows the subject unifying the thumb, index finger and middle finger and then swung in the air as if writing something. While Figure 3 shows the subject is pointing to the paper on paper in the explanation process that he did.

Embodied cognition other than the mathematical imagination used by visual subjects is Utterance, which consists of: (1) sound production and high intonation of sound and keen eye gaze at the researcher expresses high confidence on the sentence uttered; (2) the production of sound and the intonation of the voice is weakened and the gaze is looking at the researcher's eyes to express doubt as to the statement he or she is confirming; (3) eye movement as embodied cognition to express the ongoing process of thinking; (4) the calmness of the body to express the discomfort of the situation in which case the difficulty in answering through the motion of scratching the neck as well as being fixed is fixed; and (5) facial expressions to state the ongoing process of thinking through the movement of raising eyebrows.

3.2. Discussion

The results of the research show some important things to discuss, one of them which is about the quality of mathematical imagination used by students in conceptual understanding of algebraic expression. In the stages of interpreting and exemplifying, students do mathematical imagination about the variables, coefficients and constants through the objects he recognizes and the imagining mathematical operations through events in everyday life. At another stage of the process of understanding, students imagine the knowledge that they already have. This is the same way with the notion of imagination which is a person's mental activity in forming a visualization or image to combine, alter, and create new experiences or knowledge based on experience or old knowledge as the basis of mathematical knowledge [8,9]. Imagination plays a role in creating a real visualization for the subject that is necessary for all thoughts and then deciphering into a knowledge base [10].

Another interesting result to discuss is the gesture of representation which is the embodied cognition of the mathematical imagination used. In the case of gestures of representations of variables, there are two different motions produced by the subject that is the movement of forming objects directly or indirectly represents the existence of objects in mind, as shown in Figure 5 and Figure 6.

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Figure 5. Gestures of directly representation

Figure 6. Gestur of indirectly representation

Figure 5 shows the subject of moving the hand aligned and then followed the bottom down simultaneously then inverting the hand followed the left right movement together to form a box. While the picture 6 shows the subject of doing the right hand movements stretch and as if holding a large object as if it represents a large cardboard box. Both movements are in accordance with the meaning of gestue representation, ie, movements that describe semantic content, either literally or figuratively, through handshape or motion path [4]. Cognition is based on sensorimotor action and processing [11], and conceptual representation depends on sensorimotor experience. Cognitive processing involves recreation from direct sensory experience [12,13].

Utterance as an embodied cognition of the mathematical imagination students use in conceptual understanding of algebraic expression is also interesting to discuss. Sound production and intonation of the weakened voice and the subject's gaze toward the eyes of the researcher as if indicating the desire of the subject to ask the truth answers to what is spoken or as if asking what ideas should be considered to answer the problems faced to form an interaction. The interaction that arises between the subject and the researcher is a form of social interaction that a person needs, not least in the learning process. This shows that even though the subject is an active individual in the process of understanding a new knowledge, it can't escape interaction with the environment as proposed by Vygotsky which is famous for the theory of social construction [14]. The results of this study support the research that has been done Dwijayanti about the effectiveness of new knowledge construction process using the old knowledge that students have [15].

4. Coclusion

The conclusions of this research are: (1) The mathematical imaginations used in understanding the concept of algebraic expression are imaginations derived from life experiences in the form of objects that have been recognized as representations of variables, coefficients and constants and events experienced in everyday life as representations of mathematical operations; (2) Another mathematical imagination used in understanding the concept of algebraic expression is the imagination of previously possessed knowledge reconstructed to build new knowledge; (3) subjects use gestures of representation, either direct representations or indirect representations, to represent variables, coefficients or constants; gestures and writing gestures as embodied cognition of the imagination used; (4) subject uses utterance as the embodied cognition of the imagination to reinforce the pronounced statement, indicates the existence of doubt, indicates the existence of the thinking process as well as the form of social interaction that he did to obtain a confirmation or consent from the researcher.

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