Schemata's Influence On Mathematical Problem Solving Skills

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Schemata's Influence On Mathematical Problem Solving Skills

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Abstract: Schemata is one of the factors that influence a person's ability to solve problems creatively. Schemata in one's memory will determine how new information is processed into a new concept. This study aims to describe schemata's influence on solving mathematical problems. This research is categorized as qualitative research. Data of thinking schemata and solving mathematical processes are collected by the method of think out a loud and task analysis, namely by giving test questions and conducting interviews according to student responses and viewed from mathematical problem solving skills. The data are analyzed using Miles and Huberman's analysis techniques, through the three stages of reduction, presentation, and conclusion. The results showed that students' schemata varied according to their mathematical problem solving skills. Students with complete and systematic schemata (formal, content, and linguistic) structures had high mathematical problem solving skills. The process of problem solving was arranged in coherent and systematic ways with diverse answers. This happened because the adaptation process (assimilation and accommodation) and the formation of a concept scheme run well, neatly and completely. New schemata were well formed and produced balanced new knowledge. This Schemata will facilitate students to connect among concepts so that problems could be solved properly.

Keyword: schemata, mathematical problems, mathematical problem solving skills

1 Introduction

One of the purposes of learning mathematics is to improve creative thinking skills in solving problems (Nadjafikhah&Bakhshalizadeh, 2012). Creative thinking skills allow learners to produce a variety of problem solutions both the amount and the way used. Creative thinking skills are influenced by several factors. One of them is the prerequisite ability (background knowledge) previously owned. The prerequisite capabilities are the concept schemes built based on the students ' experience (Piaget, 1980). These schemes will build a system called schemata (An, 2013). Schemata is a plural form or a collection of concept schemes representing a generic concept stored in memory (Rumelhart& Norman, 1985). Schemata is a mental representation of some aspects that serve to compare the knowledge that a person has with new information that goes into his or her memory (Gardner, 1987; Cook, 1989). Schemata develops according to one's experience (Cook, 1989; Piaget, 1980; Rumelhart& Norman, 1985; Neumann, &Kopcha, 2018; Longo & Perret, 2018). Schemata is what helps someone process new information until it solves the problem given to him. The ability to process information is part of a person's biological development and knowledge, including Metacognition (Flavell, 2004). In other words, when a person is able to organize and compile information using his or her experience, he or she will also use his or her metacognitive skills more often. This is also known as creative thinking, so schemata is very close to the improvement of creative thinking and has an important role in the development of one's thinking logic (Corcoranm, 2006).

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The logic of thinking is what will help someone in solving the problems encountered including in solving mathematical problems. Schemata certainly encompass general aspects, and does not only apply to mathematics learning. In language learning, for example, schemata play a major role in improving students' reading skills, especially in terms of reading comprehension (Basmalah, 2013). Zhao & Zhu (2012) explicates further that in order to understand a text, people should "combine their own background knowledge with the information in a text. In this process, the prior knowledge and knowledge structure work effectively in people's cognitive activities" (p.111). Prior to this, Nunan (2001) shares the same argument that schemata massively influences the way we interpret the new information by offering a framework that is suitable with the new information gotten. Therefore, understanding the passage is such an interactive process among the reader and the passage, in which they should connect the hint in the text with their own schemata either it is content schemata, formal schemata, or linguistic schemata. Thus it takes the right way how to see how schemata is formed and how the schemata arrangement is stored in one's memory. This research will give an overview of how a person's schemata is constructed and develops from his mathematical problem solving skills. This research will focus on three types of schemata i.e. formal schemata, content and linguistics for geometric material builds flat.

2 Research Methodology

2.1 Participant

This research is a qualitative research with 30 students of pre-service Primary School teachers as the participants. Participant selection technique used is a non-probability sampling technique, which is taking a subject where each member of the population taken does not have the same opportunity to be the subject of research. The type of non-probability sampling used is purposive sampling, which is the taking of subjects used if the researcher has certain considerations with certain objectives.

2.2 Technique and Data Collection Instrument

Data in the form of creative thinking processes and thinking schemata are collected by the method of think out a loud (Charters, 2003) and task analysis (Someren, 1994), namely by giving test questions and conducting interviews according to student responses and viewed from the components of thinking system. This was done on the basis of Mayer's thinking (2009); Solso, Maclin & Maclin (2008) that thinking is cognitive activity that occurs in a person's mental or mind, is not visible, but can be inferred from visible behavior. The type of schemata in this study used opinions by Dixon & Zhao (2012) and Shuying An (2013) which has been modified in accordance with the needs of the research, namely about mathematics, creative thinking, geometry material of plane.

Table 1. Type and Descriptions of the Schematic in Thinking

Type of Schematic	General Definition	Special Definition in Learning to Build Plane Geometry
Formal Schemata	Schemata that refers to the initial knowledge a person has as a prerequisite knowledge to be able to understand and understand a new concept well.	Schemata that refers to the prerequisite knowledge that has been possessed before learning a plane in terms of rectangles include geometric definitions of plane geometry, geometric objects (points and lines), relationships of geometric objects (angles and distances), and types of plane geometry.
Content Schemata	Schemata referring to prior knowledge about new concepts that will be studied.	Schemata referring to prior knowledge about new concepts that will be studied are plane rectangular geometry (definition, types and characteristics, relationships between waking flat rectangle, area and perimeter of rectangles and combined Flat Flat quadrilateral)
Linguistic Schemata	Referring to the knowledge of vocabulary and grammar associated with the concepts to be learned which serve as the basis for understanding more complex concepts or knowledge.	Schemata related to knowledge about vocabulary and grammar related to 2-D shapes such as points, lines, relationships between lines (parallel, intersecting, coinciding), angles, corresponding angles, acute angle, right angle, obtuse angle, area, circumference, similar and cognruent, combination of 2-D shapes, area combination of 2-D shapes, application of the concept of 2-D shapes, problem solving related to 2-D shapes, etc.

2.3 Data AnalysisTechnique

Qualitative data analysis to analyze and map mathematical creative thinking schemes was done through several steps according to Miles & Huberman (1994), Creswell (2012) and Bazeley& Jackson (2013) namely data reduction, data presentation, and drawing conclusions.

Data Reduction

Data reduction is an activity that refers to the selection process, focusing to simplify abstracting and transforming raw data in the field. The steps of data reduction activities in this study are; 1) each level of creative thinking is taken by 1 subject, 2) the subject will be interviewed according to the answers and observations when working on the questions to get the creative thinking according to their experience, 3) based on the answers, the schematic will be mapped to the level of creative thinking and the aspect of creative thinking, 4) based on all of the data obtained then made a final summary of the subject system.

Data Display

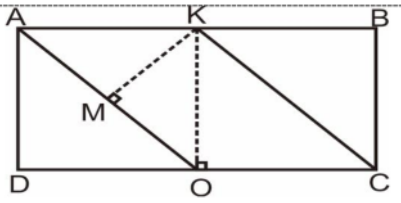
The display of data includes the classification and identification of data, namely writing organized data sets so that it is possible to draw conclusions from the data. Presentation of data in this study was presented in the form of tables and schemata in cognitive maps of each subject thus it is clear how the schema of each subject is seen from the level and aspects of creative thinking.

Drawing Conclusion

Drawing conclusions is the final stage of this research. Withdrawing conclusions was done based on the results of analysis of data that has been collected, both obtained from tests, observations and interviews. The results of the analysis at the data presentation stage were used to compile a schematic description of each subject seen from the learning style according to the level and aspects of creative thinking.

3 RESULT AND DISCUSSION

Schemata students in solving mathematical problems can be seen from the results of interviews based on the questions given and answers given by students. To give a description of mathematical problem solving schemes then selected 3 subjects with high, medium, and low categories. Here are the questions given to the subject.



The ABCD build is a rectangle. K is located right in the middle of the side AB, and O is located right in the middle of the side of the CD, length AB = 10 cm and BC = 5 cm.Determine the size of the AKCO according to the way you think until you get the right result!

Subject 1

The interview results for subject 1, there are 4 correct answers can be seen from the recap of the following interview.

Question 1	How do you respond to the questions given?
Subject 1	It's easy and I can do it
Question 2	What are the related concepts related to?
Subject 1	Build a rectangular plane, namely parallelogram
Question 3	Explain in your own language the concept?
Subject 1	Parallelogram is a rectangular plane building that has 2 pairs of parallel sides, the angles have to be

	the same
Question 4	What mathematical terms are related to this problem?
Subject 1	Side, angle, area, circumference, height, base, parallel, right angle
Question 5	Pay attention to alternative answers 1, 2, 3 and 4, what concepts do you use?
Subject 1	Parallelogram, triangle, rectangle, square
Question 6	Are there other concepts that can be used to answer this question?
Subject 1	No, only that
Question 7	Why did you choose these concepts
Subject 1	As per the picture, the concept is related.
Question 8	Tell the relationship between the concepts?
Subject 1	The image on the question consists of 4 for the same triangle, thus the area of the parallelogram can be searched from 2 times the area of the triangle. You can also use the ABCD Rectangle then subtract the area of 2 triangles. If the 2 triangles that suckle the parallelogram is arranged then it can also form a square with a side length of 5, thus the area of the parallelogram is equal to the area of square. That's all, sir.
Question 9	How can the concept be used to solve the problems?
Subject 1	Well because it is interrelated like the answer, according to the picture it has something to do with Rectangle, Square, Triangle to solve parallelogram problems.
Question 10	Do you think of new ways to solve this problem?
Subject 1	No

In accordance with the answers in the interview, then the schemata structure of subject 1 can be described below.

Type of Schemata	Note
Formal Schemata	Subject 1 had very good initial knowledge as a prerequisite concept. The concepts included angle, side, base, height, parallel, right angle, area, and circumference, even the concept of triangle, square, and rectangle. This was what facilitated subject 1 to produce several alternative answers in a variety of ways by determining the relationship between the concepts.
Content Schemata	The theme content of subject 1 was also very good. The subject understood in detail what parallelogram was as the main problem to solve. The subject was able to explain the definition and characteristics of parallelogram thus it makes it easier for the subject to solve the problem. The relationship between concepts as a prerequisite can also be associated with the parallelogram concept well, making it easier to solve problems.
Linguistic Schemata	Subject 1 linguistic / language schematic was also very good. Many terms can be conveyed by the subject such as angle, side, base, height, parallel, right angle, width, circumference, perpendicular up to straight, parallel, diagonal side, even the subject had a special term to make it easier to remember the parallelogram concept, namely parallelogram p xl only the width is the parallelogram height. This was done so that there wouldn't be too many things to be stored in the brain.

These results indicate that subjects with high categories have excellent and complete schemes in both formal, content and linguistic schemes. This is what makes the assimilation process work well. Existing concepts are well organized and can be used to solve problems. In addition, the existing concept is able to produce new ways through the accommodation process so that new concepts are found that are relationships between concepts. Subject 1 gives 3 correct answers with systematic and correct finishing steps.

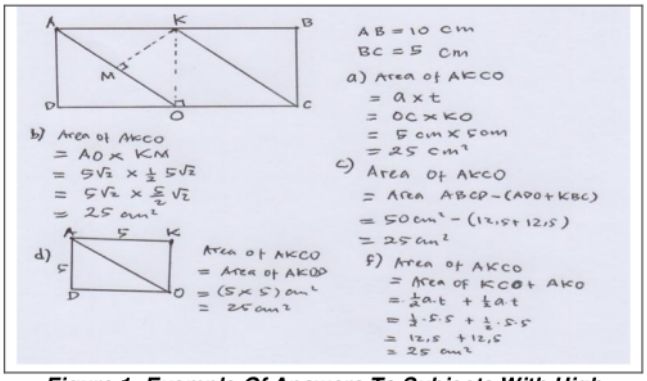


Figure 1: Example Of Answers To Subjects With High Categories

Subject 2

As per the answer to the subject 2 there are 2 correct answers. Based on this answer, interviews are then carried out and the results are as follows:

Question 1	How do you respond to the questions given?
Subject2	Make you confused at first.
Question 2	What are the related concepts related to?
Subject2	Build a rectangular plane, namely parallelogram
Question 3	Explain in your own language the concept?
Subject2	Parallelogram is a rectangular plane building
Question 4	What mathematical terms are related to this problem?
Subject2	Spacious, pedestal, high
Question 5	Pay attention to the alternative answers you produce, what concepts do you use?
Subject2	Parallelogram and Triangle
Question 6	Are there other concepts that can be used to answer this question?
Subject2	No, only that
Question 7	Why did you choose these concepts
Subject 2	The picture shows only parallelogram and triangle.
Question 8	Tell the relationship between the concepts?
Subject 2	In the picture the parallelogram is made up of 2 triangles, so the area is directly added up
Question 9	How can the concept be used to solve the problems in the question?
Subject 2	As per the picture, it has something to do with Triangle and Parallelogram
Question 10	Are there other concepts related to the problem?
Subject 2	Nothing, first when I studied parallelogram, I discussed it myself about parallelogram has nothing to do with others. This is a coincidence that I see a triangle that forms a parallelogram. Even then, I was still confused because the picture of the parallelogram was different from the usual one
Question 11	Can you describe the pattern of relations between rectangular flat shapes?
Subjek2	What do you mean, sir, I don't understand

In accordance with the answers in the interview, then the schemata structure of subject 2 can be described below.

Formal Schemata	Subject 2 had initial knowledge not yet complete as a prerequisite concept. The concepts possessed include area, base, height, and triangle. This concept helped subject 2 to produce several alternative answers.
Content Schemata	The theme of subject 2 content about parallelogram was only limited as a stand-alone rectangular building. Subject 2 only memorized the wide parallelogram ie x height. The relationship between concepts as a prerequisite was only related to Triangle because

	Subject 2 only saw that the parallelogram in the question was composed of 2 Triangles, without looking at other possibilities.
Linguistic Schemata	Subject 2 linguistic schema / language was limited to area, base, height, triangle and parallelogram. This also limited Subject 2 to produce other problem solving alternatives.

These results indicate that subject 2 with medium category has an incomplete scheme, only focusing on 2 concepts namely parallelogram and triangle. Nevertheless the assimilation process went well, especially those related to parallelogram thus it was able to provide two solutions to the problem. Subject 2 has not seen other concepts such as rectangles and squares, this causes subject 2 to only produce 2 solutions. What is interesting from the results of interviews is that learning patterns of plane was done partially, not paying attention to the relationship between plane building, so when asked about the relationship and classification the subject experiences confusion and cannot describe the relationship.

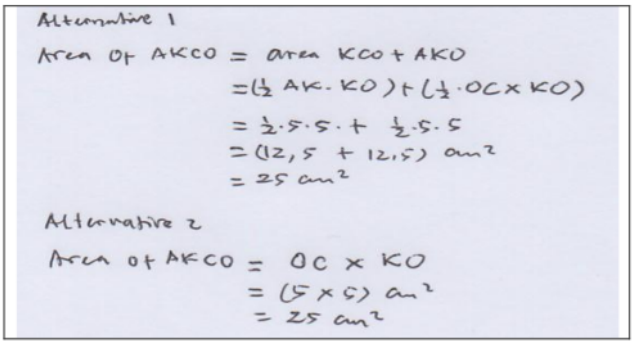


Figure 2: Example of Answers to Subjects With Medium Categories

a. Subjek 3

As per the answer to the subject 3 (less creative) there was no right answer. Based on this answer, interviews were then carried out and the results are as follows:

Question 1	How do you respond to the questions given?
Subject3	I am confused, sir
Question 2	What are the related concepts related to?
Subject3	Two-dimentional figure
Question 3	Explain in your own language the concept?
Subject3	I forgot sir
Question 4	What mathematical terms are related to this problem?
Subject3	Square, broad
Question 5	Pay attention to the alternative answers you produce, what concepts do you use?
Subject2	Rectangle
Question 6	Are there other concepts that can be used to answer this question?
Subject3	I forget
Question 7	Why did you choose these concepts
Subject3	I remember, sir
Question 8	Are you sure that your answer is correct?
Subject3	I'm not sure, sir
Question 9	Sorry, your answer is still not correct? Do you know why your answer is not correct?
Subject3	I don't know sir
Question 10	Do you like learning mathematics
Subject3	I don't like it sir
Question 11	What causes you not to study mathematics?
Subject3	It's hard, sir, and it's not good for learning. I am often scared during math class
Question 12	Good, it will be discussed after learning tomorrow. Hopefully after learning you will better understand this concept.

In accordance with the answers in the interview, then the schemata structure of subject 3 can be described below.

Formal Schemata	Subject 3 did not have good initial knowledge as a prerequisite concept. Only rectangular concepts in general, and forgot the concepts that existed in the problem given. The subject also experienced confusion in building a rectangle that was the problem. This happens because the presentation of parallelogram images was not as usual, so subject 3 was confused.
Content Schemata	The content schemata of subject 3 on parallelogram was very weak, even having difficulty identifying that the problems presented are related to parallelogram. This happens because the parallelogram images are different from the pictures presented earlier
Linguistic Schemata	The subject's linguistic schemes were only limited to rectangular flat, rectangular, wide, but many forgotten names.

These results indicate that subject 3 in the low category has an unfavorable scheme. This caused subject 3 cannot provide a solution to the problem. The assimilation process did not go well, many forgotten concepts even some were unknown to them. What's interesting about the results of the interview is that subject 3 did not like learning mathematics. Subject 3 did not feel comfortable and happy while studying mathematics, even tended to be afraid. This is what caused not many mathematical concepts stored in the subject's memory 3.

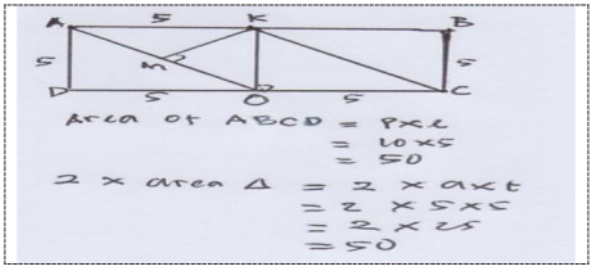


Figure 3: Example Of Answers To Subjects With Low Categories

These results indicate that schemata structure that is owned by students can influence its ability to solve mathematical problems. This will make the adaptation process run well so that knowledge will continue to develop according to the good experience received by each student (Piaget, 1980). This good adaptation process enables the formation of interrelated concept schemes, namely schemata in student memory (Rumelhart& Norman, 1985). This scheme will be the capital of students to complete the questions given to them. This is in line with the opinion of Cook, 1989; Piaget, 1980; Rumelhart& Norman, 1985; Neumann &Kopcha, 2018; Longo & Perret, 2018, that a person's scheme will develop in line with his experience. In accordance with these results, the next step is to conduct interviews related to the causes of unsuitable schemata in the memory of the student. Students with medium and low problem solving skills tend not to like mathematics since they are school in elementary school. They enter into an elementary school teacher candidate to avoid learning mathematics. This condition makes them not motivated to

learn math. Mathematics is not taught with the content of their lives, making it increasingly difficult to understand. It is not appropriate with the paradigm of learning mathematics today, where mathematics is close to humans, mathematics is part of human culture (Hersh, 1997; Greer, 1997; Rosa, 2011) and is part of social reality (Hersh, 1997; Zevenbergen, 2004). In addition, students are always faced with real problems that are interesting and challenging which are the application of the concepts to be studied. This pleasant problem is what gives students the opportunity to criticize problems in different ways and not be a pressure in their hearts carried out in groups. The results of critical thinking of each group will result in diverse and unique problem solving by adding activities that require each group to produce creative products and even new / different from the other in the form of problem solving ideas and creative products as a result of the application of the concept. This is in accordance with the thinking concept of Best & Thomas (2007); Torrance (1969) and McGregor (2007) that to produce something creative as a result of creative thinking (in this case mathematics) a process is needed to produce something and new ideas, original, to solve problems that exist well and collapse. If a person is not able to think of a solution and does not even understand the problem given, he will not be able to create a solution to the problem, especially if he has to be guided in many ways and new. Even to get creative thinking especially in mathematics, high curiosity is needed by the process of exploration and observation, as well as imagination and high originality of thought (Vale & Barbosa, 2015). If someone does not like what is being learned, their thinking process will be hampered, especially if they are required to think creatively. Student permissible is taught to take the meaning of the issue they learn. So carrying new ones they learn can be applied in everyday life. This is in accordance with the Brownell learning concept (1935), which is Meaning Theory (meaningful theory) and David Ausubel that learning will be more meaningful if it is associated with the contextual life problems of students. Student creativity in solving mathematical problems is also supported by a learning environment that fosters creativity from among students themselves (Soh, 2017,Mishra, 2017). There is an opportunity for each group to present the results in a face-to-face class, thus encouraging other groups to produce better works. This very positive learning environment triggered students with their teams to continue to improve their creative work. Positive learning environments are also provided by lecturers in the form of learning simulations by lecturers using animation media, images and even video realities of life that are close to students so that they are easy to understand. This is consistent with the results of research by Tsai & Chung, (2015), that a positive learning environment will motivate students and be creative to produce something useful.

4 CONCLUSION

The results showed that students' schemata varied according to their creativity in solving mathematical problems. Students with high creative thinking skills had complete and systematic schemata (formal, content, and linguistic) structures. The process of problem solving was arranged in coherent and systematic ways with diverse answers. This happened because the adaptation process (assimilation and accommodation) and the formation of a concept scheme run well, neatly and completely. New schemata were well formed and produced balanced new knowledge. This Schemata will facilitate students to connect among concepts so that problems could be solved properly.

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