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Students' cognitive style in mathematical thinking process

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Abstract. The process of mathematical thinking in learning mathematics is very important. One internal factor that affects it is cognitive style. The purpose of this study is to describe how each student's cognitive style performs mathematical thinking processes. The types of cognitive styles studied are field dependent (FD) and field independent (FI). This research is a literature study by examining journals related to cognitive style and students' mathematical thinking abilities. The results of journals review show that students with FI cognitive style analyze and orient analytically to process information and are able to process information using mathematical notation and their own language, and are able to model problems using image visualization. Students with FD cognitive styles adopt a global orientation to understand and process information. In solving mathematical problems, students with FI cognitive style were better than students with FD cognitive style.

1. Introduction

One of the life skills that needs to be developed through the education process is thinking skills. The ability of a person to be able to succeed in his life is partly determined by his thinking skills, especially in the effort to solve life's problems he faces. Mathematics is one of the subjects in schools that is able to develop students' thinking processes [1]. Mathematics learning emphasizes the process of thinking, attitudes, curiosity and enjoy learning mathematics.

Logical thinking skills is important in learning mathematics. It is expected that the teacher is able to develop the students' thinking skills through appropriate learning methods. An effective method for training students' thinking skills according to their individual characteristics. But in fact, learning mathematics today is still less effective for this purpose.

One internal factor that influences students' thinking processes is cognitive style. The ability to think is closely related to the way a person processes and organizes information in his cognitive activities. In processing this information, each person has a different way according to their own cognitive style. Hamzah explained Woolfok's study, that in the cognitive style, there is a different way to see, recognize and organize information [2]. Based on psychological differences, according to Prabawa and Zaenuri's study, there are two classifications of cognitive styles namely Field Dependent (FD) and Field Independent (FI) [3]. FD individuals are types of individuals who think globally and tend to be passive, while FI individuals are types of individuals who understand and process information analytically. The purpose in this article is to describe the mathematical thinking process of students in terms of cognitive style, based on the results of research that has been done.



2. Method

This research is a literature study by examining 16 journals, proceedings, and books related to cognitive style and students' mathematical thinking abilities. The results of this literature review will be used to identify how students' mathematical thinking processes with field dependent and field independent cognitive styles in mathematics learning. I selected articles that published from 2006 to 2018, where the cognitive style of students in mathematical thinking began to be widely researched in Indonesia and internationally.

3. Results and discussion

3.1. Cognitive Style

Cognitive style is an individual preferred and habitual approach to organizing and representing information, which subsequently affects the way in which one perceives and responds to events and ideas [4]. Allport defined cognitive styles as the habitual way in which an individual processes different information, while Friend and Cole have expanded the definition of cognitive styles to include the way in which the individual perceives, codes, saves and recalls information [5].

According to Saracho, cognitive styles include stable attitudes, choices, or habit strategies that distinguish individual styles from feeling, remembering, thinking and solving problems [6]. Different researchers identified different types of cognitive styles such as field dependent and field-independent, reflective and impulsive, wholist and serialist, verbalizer and visualizer [6]. This is only a very small sample of the different types of cognitive styles that one encounters in the literature. A study conducted by Riding and Cheema reviewed over 30 methods of defining cognitive style and concluded that most could be grouped within two fundamental independent cognitive style dimensions, the verbal–imagery dimension and the wholistic–analytic dimension [6]. This paper will be discussed about field independent (FI) and field dependent (FD) cognitive style.

According to Desmita [7], the character of learning in students who have independent field cognitive style is (1) may need help focusing attention on material with social content, (2) it may need to be taught how the context to understand social information, (3) tends have self-goals that are defined and reinforcement, (4) are not affected by criticism, (5) can develop their own structure in unstructured situations, and (6) are usually better able to solve problems without explicit instructions and guidance.

In contrast to the independent field cognitive style, the character of learning in students who have a field dependent cognitive style is (1) it is easier to understand learning material by containing social content, (2) has a better memory for social problems, (3) has a structure, objectives, and reinforcement that are clearly defined, (4) are more influenced by criticism, (5) have great difficulty in learning structured material, (6) may need to be taught how to use mnemonics, (7) tend to accept given organizations and are unable to organize again, and (8) may require clearer instructions on how to solve the problem.

Rahman and Ahmar [8] mentioned the implications of students' cognitive styles in learning of field-independent and field-dependent are as follows: (1) Students with the cognitive style of field-independent learn mathematics individually, enabling them to provide better responses, and are more independent. Those with this cognitive style are more likely to learn mathematics by intrinsic motivation and are inclined to work to satisfy their own ambition. (2) Students with the cognitive style of field-dependent learn mathematics in a group and frequently interact with their teacher, requiring extrinsic reinforcement. For those with this cognitive style, a teacher is required to design what should be undertaken and how to undertake it. Such students require guidance from the teacher and motivation is such reward and encouragement.

3.2. Mathematical Thinking Processes

Siswono explained that thinking is a mental activity experienced by someone when faced with a problem that must be resolved [9]. Meanwhile, Ormrod defines the thought process as a way of mentally responding to information or an event [9]. So, the mathematical thinking process can be interpreted as a mental activity to process information or solve mathematical problems.

Ngilawajan [10] states that thinking is information processing. When children *perceive, encode, represent, and store* information from the world around them, then they are doing a thought process. For can stimulate and train students' thinking skills in learning mathematics, it is necessary to use appropriate methods or techniques in learning that can stimulate students to use all the potential think that is owned. Problem solving is one way in learning to train students to think and this has been proven by experts through a number of studies.

Scusa [11] mentions five mathematical thinking processes: 1) problem solving as a process, 2) the process of reasoning and proof. 3) the communication process 4) the process of representation, dan 5) making connections as a process skill.

3.3. Students' cognitive style in mathematical thinking processes

Amstrong [12] mentioned the characteristics of FD and FI cognitive styles. FD individuals adopt a global orientation to perceiving and processing information; passively conform to the influence of the field or context; adopt an inter- personal approach to problem solving; and prefer to work in unstructured situations. At the other extreme, target items are perceived as being separate from the surrounding context (field independent, FI). FI individuals adopt an analytical orientation to perceiving and processing information; experience target items as discrete from their field or context; value precision and attention to detail; adopt an impersonal approach to problem solving; and prefer structured situations.

The results of Agoestanto's research about mathematics critical thinking students in junior high school based on cognitive style are: (1) the ability to think critically mathematical junior high school students are still; (2) in terms of cognitive styles critical thinking skills mathematical junior high school students with a higher FI cognitive styles of the students FD; (3) From the aspect of student's critical thinking aspect with FI cognitive style is better than the FD on the viability inference, assumptions, deduction, and argument evaluation [13].

The research which is conducted by Almolhodaie [14] found that FI way of thinking may promote higher performance in math's problem solving compared with FD way. Moreover, as was discussed, students with an FI cognitive style demonstrated higher results than FD ones in tackling the complexity of word problems, according to presented study. However, differences in performance in word problem exam were significantly higher than ordinary exam.

Based on the analysis of obtained data that in solving the problem with Polya's steps, field dependent subjects are able to understand the problem but still uses mathematical language that resembles the problem, unable to devise a plan on a particular problem that requires deeper analysis, unable to carry out the plan properly on certain questions that require more analysis and look back the answer but cannot correct the mistake [6].

Based on the findings of Marifatun, Sulistyorini, and Ahmad [15], in problem solving activities, field independent subject can understand the problem well, the subject can write down the elements that are known and asked from the problem completely and correctly. While the subject of the dependent field category can understand the problem quite well; the subject can write the elements that are known and asked from the problem well but still use everyday sentences.

The research results of Udiyono and Yuwono [16], there is a positive correlation between cognitive style and students' learning achievement on geometry subject. The coefficient determination is $r^2=0.6209$. It means the increase and decrease of students' learning result on geometry subject 62.09% can be explained by cognitive style with linear correlation equation $Y = -2.9650 + 4.6513X$. The mean score of students FD is 16 while students FI is 59.5385. It means students FI has better learning achievement than students FD on geometry subject.

4. Conclusion

Mathematical thinking process is a mental activity to process information or solve mathematical problems. While the way of receiving and processing information, attitudes towards information and habits related to the learning environment are called cognitive styles. There are two kinds of cognitive styles namely field dependent (FD) and independent field (FI).

In the process of mathematical thinking, students with FI cognitive style analyze and orient analytically to process information and are able to process information using mathematical notation and their own language, and are able to model problems using image visualization. In contrast to students with FD cognitive styles who adopt a global orientation to understand and process information. Based on several studies that have been conducted, it was found that students' thought processes in solving mathematical problems with FI cognitive style were better than students with FD cognitive style.

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