

Characteristic of critical and creative thinking of students of mathematics education study program *by Arief Agoestanto*

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Characteristic of critical and creative thinking of students of mathematics education study program

Rochmad^{1,*}, A Agoestanto¹ and M Kharis¹

¹ Mathematics Department, Mathematics and Natural Sciences Faculty, Semarang State University

* Corresponding author: rochmad@mail.unnes.ac.id

Abstract. Critical and creative thinking give important role in learning mathematics for mathematics education students. This research to explored the characteristic of critical and creative thinking of students of mathematics study program in mathematics department. Critical thinking and creative thinking can be illustrated as two sides of a coin, which one is associated to the other. In elementary linear algebra courses, however, critical thinking can be seen as a foundation to build students' creative thinking.

1. Introduction

One of the factors that influence student's mathematics learning outcome is the characteristic of students thinking. This student's thinking characteristic can be seen as behavioral input (entering behavior). Winn as quoted by Saurino, said that: 'Teachers should facilitate students to think critically, or else the society will suffer for a long time due to the absence of critical thinking in learning [1]. Factors that affect the ability of students of mathematics learning, among others, intelligence and students performance.

Undergraduate Program of Mathematics Education, Mathematics Department, Faculty of Mathematics and Natural Sciences, Semarang State University; one of the tasks and functions of preparing candidates for mathematics teachers in schools, so as the teachers candidate trying to know overcome and anticipate problems of students' difficulties in learning mathematics. Teachers are key factors in the qualitative development of education systems [2]. One of them through how to improve the ability in the cognitive domain related to critical and creative thinking. Arends [3] stated that 'though critical thinking skill is the main aspect in higher education, in fact the lecturer rarely use effective method to encourage students to use critical thinking strategy.' Therefore, it is necessary to conduct a research in order to find out the characteristics of critical and creative thinking mathematics undergraduate students of mathematics study program.

One of the factors that influence of student learning outcomes is the characteristics of students thinking [4]. The characteristics of these students can be viewed as behavioral inputs (entering behavior). Factors that affect the characteristics of students, among others, intelligence and maturity of students. In learning mathematics the characteristics of critical and creative thinking very important for students. Both helped deliver their minds when solving a problem. For some lecture-based classes, using active learning may be a bit more challenging because of class size or room limitations such as fixed seating. Breaking students into groups under these circumstances may not be possible, but other strategies such as individual writing or paired activities are quite possible and lead to good results [5].



Critical thinking is purposeful, reasoned and goal-directed in teaching and learning [6]. Teacher candidates, as being students currently, needs to their improve critical thinking skills and, as being teachers in future, are required to know the ways of improving their clients' skill of critical thinking [7, 8]. It is the kind of thinking involved in solving problems, include formulating inferences and making decision [9]. Most of the models of critical thinking include five steps: elementary clarification, advanced clarification, inference, judgment and strategies. But Perkins and Murphy used four indicators to investigate students critical thinking, namely clarification, assessment, inference, and strategy; and they have attempted to provide a indicators of critical thinking that could be used efficiently and easily to derive and present student profiles of engagement in critical thinking [10].

The purposed of writing this article to described the results of research on the characteristics of mathematics critical and creative thinking of undergraduate students of Mathematics Education Study Program. This research is in the field of algebra, in elementary linear algebra course. This fields are considered as the main courses containing basic concepts and underlying thoughts in studying algebra and other mathematical concepts and materials.

2. Methods

This research was qualitative research. Researchers as the main instrument in this study. The subjects of this study were students who took the Elementary Linear Algebra 2 in the even semester of the lecture year 2016-2017, Mathematics Education Study Program, Mathematics Department, Faculty of Mathematics and Natural Sciences Semarang State University.

Data collection techniques and analysis as follows. In general there were four kinds of data collection techniques, as follows. Test, written test to know the character of critical and creative thinking. The critical thinking test is based on critical thinking indicators, and the creative thinking test is based on indicators of creative thinking. Observation, in this study we used passive participatory observation, researchers were not involved with daily activities in lectures being observed or used as research data sources. Passive participation, in this case the researcher arrived at the observed lecture, but is not involved in the activity in teaching and learning. Lectures was taught by lecturers other than researchers. Interview, in this research conducted interviews with interviews structured, semi-structured, and unstructured. Triangulation, was done as a data collection technique that combines from various data collection techniques and data sources that already exist. The purpose of triangulation in this study didn't to seek the truth about some phenomena, but rather on increasing understanding of what is found. For example from lecturers in the group of algebra.

The analysis data was conducted on the result of 36 students' worked on elementary linear algebra 2 with descriptive analysis referring to critical thinking indicators: clarification, assessment, inference, and strategy [10]. And creative thinking indicators: fluency, flexibility, originality, and elaboration.

3. Result and Discussion

Based on the analysis conducted on each indicator of critical thinking ability, the findings of critical thinking characteristics of students as follows.

Clarification phase: student has main objective to provide problem formulation of the given problem accurately and correctly. Characteristics of critical thinking as follows: student thought to understand the direction and purpose of the given problem; observing in detail the validity of the information contained in the question; revised of problems with simple language and in accordance with the rules of the applicable mathematical language in the form of written.

Assessment phase: student has main objective to describe and write down the questions contained in the problems found. Characteristics of critical thinking as follows: student recognized the aspects used as information in the problem; described the information contained in the matter into separate parts; identified for logical and relevant reasons related to how the validity and truth of the information on the matter; strengthen the argument by using examples; linked the issues with the others related

concepts; seek and rewritten the required requirements by redefined concepts at the problem; and planned the stages of problem solving that will be done.

Inference phase: student has main objectives to make conclusions or generalizations using logical reasons based on relevant criteria and standards. Characteristics of critical thinking as follows: student ensured that the minimum requirements required to answer the questions are met; answered the problems given with the information already owned to find a solution; strengthen the argument by using many examples; made a logical conclusions of the solution of the problem obtained.

Strategy phase: student has main objective to poured open thoughts, ideas, and explain openly to a problem. Characteristics of critical thinking: student rephrased the problem in more detail; evaluated the troubleshooting process that has been done; redefined the given problem; reconnected the explanation results with other concepts that may be related; and try to reworked the new information so as to generated problem solutions in several different ways.

In exploring the initial research on characteristic of critical thinking, there are quite a variety of opinions defining it. Most problem solving models, according to Jacob and Sam [10], have the following steps of occurrence: (1) representing problems (2) searching for solutions and (3) implementing them. The rational activities of critical thinking are often associated with problem solving. Critical thinking need solving a problem, in general critical thinking involves reasoning about an open ended problem, although a mathematical problem solving in classroom is usually considered narrow in scope as routin problems.

According to Arends [3] critical thinking appears to be best encouraged among students when a more consistent emphasis is placed on the discussions, and when instructor facilitation is less frequent but more purposeful. Taking into consideration the complexity of the concept of critical thinking and literature review obviously it is not easy to define critical thinking and there is not a single definition of critical thinking [4].

Based on the analysis performed on each indicator of creative thinking ability, the following findings of creative thinking characteristics are found. Characteristics of thinking on aspects of fluency: students understood the direction and purpose of the given problem; described the problem in more detail and tried to find the initial data; linked data findings with existing concepts; and solved problems systematically and coherently to obtained a solution.

Characteristics of thinking on the aspects of flexibility: students described the problem-solving process that had been done as a form of evaluation; developed insights related to the possibility of a connection between preliminary data and other relevant concepts; developed a completion framework so that new combinations were possible to find a solution; and tried to reworks the new found data so that the problem solution was generated in several different ways.

Characteristics of thinking on the aspects of originality: students re-examined the steps and completion process that has been done; tried to make a combination of solutions that others might not though; and tend to thinked of finding new things both in processes and products.

Characteristics of thinking on the aspects of elaboration: students re-evaluated the troubleshooting process that has been done; developed a broad insight into the possibilities of developing the problem; described the findings by connecting information received with the concepts that have been owned; and connected existing information with existing concepts to detailed the findings.

A review of the literature about mathematical creativity reveals different definitions and various approaches and interpretations. Creativity plays a significant role in mathematics. Hargrove and Greenstein revealed that creative thinking was one of the high-order thinking skills which was very important to be developed in the 21st century [11]. However, they focus on the different aspects of creativity. For instance, mathematics educators focus on the teaching practices in the classroom, whereas mathematicians focus on mathematical creativity, which concentrates more on the nature of mathematics [12].

4 Creative thinking is a kind of mathematical thinking in solving mathematical problems. Mathematical ability of students creative thinking is a component that must be mastered by the student [13]. Mathematical creative thinking plays an important role, in solving the problem in high school

students. Indonesian mathematics curricula, and also in higher education, emphasize the development of students' critical and creative thinking in all aspects of learning material. Creativity is an main part of mathematics learning and has been proposed as one of the major components to be included in mathematics education, since the essence of mathematics is creative thinking.

4. Conclusion

In studying mathematics need the ability to think critically and creatively; to be able to think critically and creatively lecturers and students are expected to understand its characteristics, especially in elementary linear algebra. In elementary linear algebra students think critically through the stages on the aspects of clarification, assessment, inference, and strategy; and creative thinking through stages on the aspects of fluency, flexibility, originality, and elaboration. In studying elementary linear algebra, students to be able to think creatively students need to have the ability to think critically.

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