Connection Between Aspects of Algebraic Creative Thinking of Undergraduate Students of Mathematics Education Study Program

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Connection Between Aspects of Algebraic Creative Thinking of Undergraduate Students of Mathematics Education Study Program

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Abstract

This article was prepared based on qualitative research, case studied with research subjects 36 undergraduate students of mathematics education study program FMIPA UNNES in elementary linear algebra. Intended to find out students' problem solving abilities aspects of algebraic creative thinking and to describe connections between aspects of students creative thinking in solving problems. Aspects of creative thinking include: fluency, flexibility, novelty, and elaboration. Data obtained through tests, observations, and interviews. Based on the analysis of the test results, as many as 17 students reached the minimal criteria which is at least 61, and 15 students worth under 61. This indicates that many students had difficulty in solving problems of elementary linear algebra that contain aspects of creative thinking. The creative thinking character of students in solving problems of elementary algebra with aspects of creative thinking; based on data analysis, obtained information that students in solving problems generally tend to thought on aspects of fluency. Some students had difficulty thought in terms of flexibility. Only a few students thought of the novelty aspect. Many students had difficulty thought about aspects of elaboration. In connection between aspects of creative thinking there were several sequence patterns in thought when solving problems. Only a few of the four aspects of creative thinking were patterned on the minds of students.

Keywords: Thinking, connection, creative, aspects, problem solving.

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1. Introduction

In learning at school and in college, mathematics is one of the servants of the science of fundamental science, which is often referred to as the *queen of sciences*. Various opinions of education experts, including Acharya (2017), argue that mathematics has been accepted as an important component of formal education since ancient times to the present. Thinking is essential in solving problems. Everyone needs mathematics. Because of that since time immemorial until now mathematics has become a subject in schools. In everyday life people need mathematics. Unal (2017) argues that someone

who has weak basic skills in mathematics will has difficulty learning mathematics at his school and in his social life.

To be able to achieve strong mathematical abilities, learning is needed. And one's mathematical abilities are reflected in the ability to solve mathematical problems. At school, a teacher or mathematics lecturer must be proficient in solving problems. Isik and Pilten (2017) stated that the lack of the ability of the teacher to solve the problem is the fundamental problem that is often encountered in mathematics classes.

The ability of students or students in creative thinking becomes the main capital in solving problems. Especially for students in higher education requires creative thinking skills in solving *open-ended problems*. According to Hu *et al* (2017), problem solving is closely related to creativity in connecting logic; as found there are several problems that need to be solved by creative thinking, in this case the product is called creativity.

In learning mathematics requires the ability to think creatively. According to Sheffield (2017), mathematicians understand that mathematics is a creative subject, but most students are less aware of it. Students are less aware that mathematical problem solving contains aspects of creative thinking. Therefore, it can be said that through mathematics provides an opportunity for students to learn creative thinking. This shows the importance of attention to aspects of the ability to think creatively for students who are studying mathematics.

Because the reason that aspects of creative thinking skills are needed in solving mathematical problems; students should recognize it well. Tabach and Friedlander (2013) argue that a student to be able to be mathematically creative must be able to think more deeply based on knowledge that has been previously possessed. Sharma (2017) argued that an idea can be said to be creative if the idea is new, foreign, or not as usual. Ultrnov and Masalimova (2017) argued that creative people will easily adjust to new conditions, find ways to overcome difficulties, and achieve higher productivity. Mainly in the aspects of creative that refer to activities producing new ideas, approaches, or actions (Leikin *et al*, 2013). If someone has creativity, he will be able to solve problems and even look for alternative solutions or the best solution (Arikan, 2017).

Based on the description of expert opinions and facts in the field, in this article we will examine the characteristics of the creative thinking ability of undergaduate students of Mathematics Education Study Program. Aspects of thinking ability that will be assessed are fluency, flexibility, originality, and elaboration. In this article, we will present a description connection between aspects of creative thingking ability.

2. Methods

This study was a qualitative study, a case study was conducted with a research subject of 36 undergraduate students of Mathematics Education Study Program, Department of Mathematics, FMIPA UNNES who attended elementary linear algebra-2. The study was conducted during the learning process. Data was collected through observations, written formative tests, and interviews. Written tests are conducted in the middle of the semester.

Qualitative description of the characteristics of creative thinking ability is also supported by observation and interview techniques. Observations were carried out during group discussions, to see the activity and process in group discussions. To obtain information about the characteristics of creative thinking, students with a formative test score in the excellent category were interviewed. As a form of triangulation on the answers to written tests made by these students. This is also done as a triangulation that focused on aspects of the students' creative thinking ability. The results of research described and discussed qualitatively. Analysis of the student answers based on four aspects of creative thinking abilities, namely (1) fluency,(2) flexibility,(3) originality, and (4) elaboration.

For algebraic problem solving abilities that contain aspects of creative thinking, the assessment is on a scale of 0-100. The aspects of creative thinking are judged by scoring; with the lowest score of 0 and highest 4. This assessment is used in order to describe the connection between aspects of creative thinking. The fluency aspect refers to the ability to express solutions smoothly and clearly. In this aspect, the maximum score is obtained if the student is able to answer with a correct and systematic algorithm, while the minimum score is obtained if the student is not fluent (or does not provide an answer). The flexibility aspect refered to the ability to get lots of ideas and look at and solve problems in various ways. The maximum score on this aspect is given if students are able to provide more than one solution to the problem that is directed and the results are correct, while the minimum score is given if students do not provide a solution to the problem.

The aspect of authenticity is seen from the ability of students to produce ideas or ways that are relatively new. The maximum score is given if students are able to provide directed, correct and non-routine answers. Minimum score on the authenticity aspect is obtained if students do not provide solutions to problems. The elaboration aspect refered to the ability of students to broaden their mind. In this aspect the maximum score

is given if the student is able to detail in explanation or generalize to the problems given, while a minimum score is given if the student does not provide a solution to the problem.

3. Results and Discussion

After the problem solving ability test was carried out on 36 students who attended on elementary linear algebra-2. Data obtained from student answers were in the form of completion the task. The results of the students' problem solving abilities based on the test results as follows, are presented in Table 1.

TABLE 1: Values of formative test of the elementary linear algebra-2.

No	Code	Value	No	Code	Value
1	A1	82	**19**	A19	34
2	A2	38	**20**	A20	82
3	A3	74	**21**	A21	86
4	A4	66	**22**	A22	80
5	A5	62	**23**	A23	74
6	A6	46	**24**	A24	78
7	A7	34	**25**	A25	52
8	A8	36	**26**	A26	64
9	A9	88	**27**	A27	86
10	A10	62	**28**	A28	70
11	A11	94	**29**	A29	48
12	A12	70	**30**	A30	74
13	A13	76	**31**	A31	56
14	A14	42	**32**	A32	62
15	A15	68	**33**	A33	54
16	A16	48	**34**	A34	24
17	A17	78	**35**	A35	14
18	A18	56	**36**	A36	52

The values in Table 1, if converted in letter values, get an A score of 4 students. The value of AB is 2 students, B value is 7 students, BC value is 4 students, C value is 4 students, CD value is 5 students, D value is 4 students, and E value is 6 students.

Based on data analysis shows aspects of the students' algebraic creative thinking abilities appear in student answers. Through analysis of the test worked that not all students had equal algebraic creative thinking abilities. Trianggulation through interviews based on the results of the test answered were shown the students tend to grown to creative thinking abilities. There were connection between aspects of students creative thinking. The following shows the connection pattern between aspects of creative thinking.

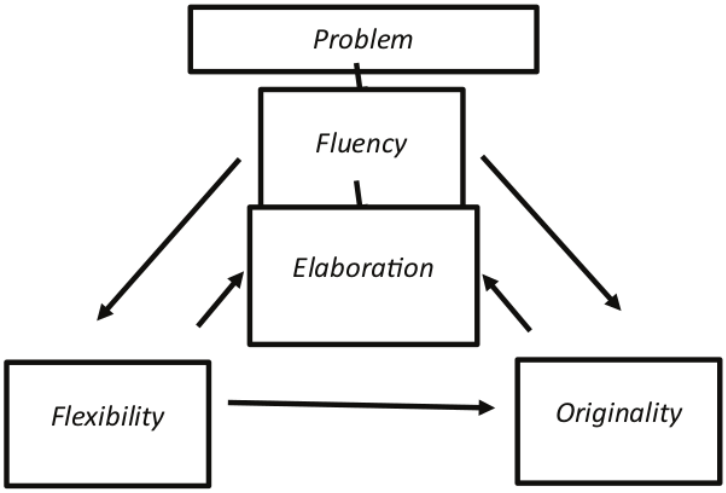

Figure 1: Connection between aspects of creative thinking in solving problems.

Figure 1 shows how aspects of creative thinking are interconnected. There are several patterns that can be formed from the algebraic creative thinking aspects namely *Problem-Fluency* (PF_1), *Problem-Fluency-Elaboration* (PF_1E), *Problem-Fluency-Originality* (PF_1O), *Problem-Fluency-Originality- Elaboration* (PF_1OE), *Problem-Fluency-Flexibility* (PF_1F_2), *Problem-Fluency-Flexibility-Elaboration* (PF_1F_2E), *Problem-Fluency-Flexibility-Originality* (PF_1F_2O), and *Problem-Fluency-Flexibility-Originality-Elaboration* (PF_1F_2OE).

The PF_1 pattern means that students are only fluent in providing a solution to the problem. The PF_1E pattern shows that students are not only fluent in providing one solution but are also able to specify or describe problems. The PF_1O pattern means that students smoothly provide one solution to a problem that can be categorized differently from other student solutions. The PF_1OE pattern shows that students are not only able to provide a solution to problems that are different from others, but also able to specify or expand the problems given.

PF_1F_2 pattern means that students are only fluent in working and more than one solution to the problem. The PF_1F_2E pattern means that students are fluent in working, giving more than one solution, and also able to specify or describe problems. The PF_1F_2O pattern shows that students are fluent in working, giving more than one solution with one or more of the solutions categorized differently from other student solutions. The PF_1F_2OE pattern shows that students are fluent in working, giving more than one solutions to the problem in which one or more of the solutions given is different from the

other students, also able to specify or expand the problem given. There is one student with a complete pattern of PF_1F_2OE.

4. Conclusion

The ability of creative thinking is important for undergraduate students of mathematics education study program in relation to solving algebraic problems. To be able to think algebraic creative, broad thinking is needed related to concepts and relationships between concepts and algorithms in solving problems. Lack of understanding the concepts and knowledge related to the problem and the inability of students in composing algorithms can make the obstacle in every aspect of creative thinking; therefore students need to understand the aspects of algebraic creative thinking. There are several connections between aspects of algebraic creative thinking in the steps of solving problem of elementary linear algebra of undergraduate students of Mathematics Education Study Program, FMIPA UNNES.

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