Analysis of mathematic creative thinking skill with the material of matrix

A P Yuniarti1, I Pramudya1, I Slamet1
1Departement of Mathematics Education, Teacher Training and Education Faculty, Sebelas Maret University

*Corresponding Author: alsapermata25@gmail.com

Abstract. Creative thinking skill is an ability to provide possible ideas and logical answers based on the information provided. The research aimed to identify and describe the creative thinking skills of mathematics. The type of this research was a qualitative descriptive research. The sampling technique used purposive sampling. The results showed that of the 5 subjects, 20% of the subjects were unable to show the three indicators of creative thinking abilities in mathematics (not creative), 40% were able to show indicators of fluency (less creative), 20% were able to show Originality (creative enough), and 20% were able to show indicators of fluency and flexibility (creative).

Keywords: Creative Thinking Skill, Mathematics, Matrix

1. Introduction
Activity that can never be separated from human life is learning. In the Big Indonesian Dictionary, the meaning of learning is “trying to gain intelligence or knowledge”. In certain sentences it can mean “practice” and also means “change in behavior or response caused by experience”. Learning is a system that is contained in the learning process [1]. Learning can be done in a formal environment such as school or non-formal such as the environment where someone lives.

School is a means of teaching and learning process activities or as a means designed for student learning under the supervision of the teacher [2]. Thus, schools become the dominant place for students to carry out learning activities. Students are expected to be able to adapt as best as possible to their environment and will bring about changes in themselves that can be useful in people’s lives [3]. In schools, various branches of knowledge that cannot be obtained from a non-formal environment are studied, both social and natural sciences. Learning must be able to achieve the expected goals.

One of the branches of science is mathematics. Mathematics is a science that deals with or examines abstract forms or structures and the relationships between them [4]. Humans, whoever it must be in contact with mathematical concepts, at least those that involve basic calculations, such as addition, subtraction, multiplication, and division which must be mastered perfectly [5]. When viewed from the classification of the field of science, mathematics enters into exact sciences which requires more creative thinking than memorization [6]. Therefore, mathematics is important for human life, so that mathematics is studied from elementary school to college level. Another fact shows that mathematics learning in Indonesia tends to be low. According to data from the Trends International Mathematics and Science Study in 2015, the average score of mathematics achievement in Indonesia was ranked 44th out of 49 countries [7].
Mathematics learning is expected to have the ability to think logically, analytically, systematically, critically, creatively and have the ability to work together [8]. In the 2013 curriculum, with the existence of Government Regulation Number 17 of 2010 concerning the Management and Implementation of Education, it states that the purpose of implementing education is to build a foundation for the development of potential students to become knowledgeable, competent, critical, creative, and innovative human beings. Therefore, creative thinking skill is one of the goals of learning mathematics in the 2013 curriculum. The creative thinking skill is the ability to find many possible answers to a problem [9]. The creative thinking skill is also needed in facing the increasingly rapid development of science and technology [10].

Creative thinking skill is important in the 21st century, but in fact the creative thinking skill of students in Indonesia is still relatively low [11]. This is in line with the results of research conducted by Andiyana in 2018 which showed that the level of students’ creative thinking skills was still low [12]. The Global creativity Index shows that Indonesia is ranked 115 out of 139 countries in terms of creativity [13].

Creative thinking (also called divergent thinking) is to provide various possible answers based on the information provided with an emphasis on the variety of numbers and suitability [14]. Creative thinking is a thought process that produces a wide variety of possible ideas and ways [15]. Pohkonen defined creative thinking as a combination of divergent and logical thinking based on intuition but still in awareness [15]. If students do not have adequate creative thinking skills, it is likely that students will not be able to solve math problems quickly, accurately and correctly [16]. More than 50% of MA students have sufficient mathematical creative thinking skills, however, the level of creative thinking abilities of students varies, ranging from very poor to very creative[17]. Matrix material can be used to cultivate students’ creative thinking skills [18]. In everyday life, the matrix concept is used intentionally or not, especially for those who are pursuing a higher education level.

So, in this research the creative thinking skill is an individual’s ability to provide possible ideas and logical answers based on the information provided. Each individual student’s creative thinking ability is different. The ability to think creatively in mathematics is influenced by several factors, ranging from factors, including the learning process carried out by teachers in schools [19]. This article aims to identify and describe students’ creative thinking skills in matrix material.

2. Research Method

The type of this research was descriptive qualitative, the data described is the creative thinking skill of mathematics. The place of research was carried out at MA Negeri 2 Ngawi. The research implementation time was in November 2019.

The subjects of this study were 5 students of class XI MIPA 1 in the 2019/2020 school year. The sampling technique was purposive sampling. Purposive sampling is the selection of data sources that are fully held by researchers who are selective with certain considerations [20]. The object of research was students’ creative thinking skills in the matrix material at MA Negeri 2 Ngawi.

The instrument used to collect data in this study was a test description instrument. This test aimed to determine students’ creative thinking skills in solving matrix problems. The test instrument consists of 3 item questions with an indicator of fluency, which is the student’s ability to respond to a problem quickly and correctly, flexibility is the student’s ability to provide problem solving in many ways and Originality is the ability of students to provide ideas/different ideas in solving problems.

The data analysis technique in this research was descriptive analysis technique. The data analysis used was to describe students’ creative thinking skills in solving problems related to the matrix. The creative thinking skill in this research was divided into 5 levels, from level 0 to level 4. The grouping of students was determined based on data obtained from previous tests.
Students measured their level of creative thinking skill based on the results of tests that have been done. The level of creative thinking skill is in Table 1 [21]:

**Table 1 Student’s level of creative thinking abilities**

| Level                  | Characteristics                                                                 |
|------------------------|---------------------------------------------------------------------------------|
| Level 4 (very creative)| Students are able to show fluency, flexibility, originality, or flexibility and originality in solving problems. |
| Level 3 (creative)     | Students are able to show fluency and flexibility, or fluency and originality in solving problems. |
| Level 2 (creative enough)| Students show flexibility or originality in solving problems.                      |
| Level 1 (less creative)| Students show fluency in solving problems.                                        |
| Level 0 (not creative) | Students are not able to show fluency, flexibility, and originality in solving problems. |

The Creative Thinking Skill Indicators in this study are as follows in Table 2:

**Table 2 Indicators of Creative Thinking Skill in Research**

| Creative Thinking Component | Indicator                                                                 |
|-----------------------------|---------------------------------------------------------------------------|
| Fluency                     | Students solve problems fluently and correctly.                           |
| Flexibility                 | Students solve problems with more than one different idea.               |
| Originality                 | Students have new ideas to solve a problem.                               |

3. Results and Discussion

3.1 Results
The results of the written test student’s mathematical creative thinking skill in MA 2 Ngawi can be seen in Table 3.
### Table 3 Test results of a Creative Thinking Skills

| No. | Students Initials | Name | Indicators | creative thinking abilities rate | percentag e |
|-----|-------------------|------|------------|---------------------------------|-------------|
| 1.  | AR                |      |            | Enough creative                  | 20%         |
| 2.  | AS                |      |            | Not creative                     | 20%         |
| 3.  | MF                |      |            | Less creative                    | 40%         |
| 4.  | RO                |      |            | Less creative                    |             |
| 5.  | MMR               |      |            | Creative                         | 20%         |

**Creative Thinking Skill Test**

**Fluency**

Determine the inverse of the matrix \[
\begin{pmatrix}
1 & 2 & 1 \\
2 & 3 & 4 \\
1 & 2 & 3
\end{pmatrix}
\]

**Flexibility**

Turn the following system of linear equations into a matrix, then look for the x, y and z values! Use more than one method!

\[
\begin{align*}
2x + yz &= 1 \\
x + y + z &= 6 \\
x - 2y + z &= 0
\end{align*}
\]

**Originality**

Sinta is 2 years younger than Yuli’s age. If they are 18 years old, determine the age ratio of Sinta and Yuli in the next 4 years!

Analysis of examples of subject answers with level 0 creative thinking skills is seen in Figure 2.

From the answers to questions 1 and 2 in the second subject, it shows that the second subject is unable to show fluency indicators of the creative thinking skill in mathematics. The second subject was not able to work on the questions fluently and correctly, the students answered the questions immediately without the process of working on the questions, and the students’ answers were also incorrect. In question no 2, the second subject is still wrong in making a matrix model of the problem. The subject basically only works on problems with the method that has been taught on the material of linear equations, without
being able to combine in a way that has been learned. The second subject was also unable to answer question number 3. The second subject was unable to find the correct flow of work, which resulted in the student not working correctly on question number 3, therefore, the second subject was unable to show originality in the ability to think creatively in mathematics.

Analysis of examples of subject answers with level 2 creative thinking skills is seen in Figure 3.

The answer to the first subject on the written test questions on creative thinking skills can be seen that students are able to answer questions fluently, but students are not able to answer correctly. Therefore, students in the first subject did not fulfill the fluency indicators of the creative thinking skill in mathematics. The first subject also did not show indicators of flexibility in working on question number 2 on the test of mathematics’ creative thinking skill, the first subject could only work on the questions in one way, namely by using a determinant matrix to find the x, y and z values. However, the first subject was able to show originality in the creative thinking skill in mathematics by being able to work on problems in new ways.

Analysis of sample answers to the subject with the level of creative thinking ability level 1 is seen in Figure 4 and Figure 5.
From the answers to questions number 2 and 3 in the third subject shows that students have not been able to show indicators of flexibility and originality. In question number 2 the students were able to answer the questions correctly, but the students only gave one method when answering the questions. This shows that students have not been able to fulfill the indicator of flexibility in creative thinking skill in mathematics. The third subject was able to answer question number 3 correctly, but students worked on the problem in a way that was usually used and had often been exemplified by the teacher, so that the third subject student was not able to show originality in the creative thinking skill in mathematics.

The third subject student has shown indicator of fluency because he is working on question number 1 fluently and correctly.

In the fourth subject, students have not been able to show indicators of flexibility and authenticity in the creative thinking skill in mathematics with the same errors as the mistakes made by the third subject. The fourth subject is also able to work on question number 1 fluently and correctly, so that student is able to show indicator of fluency in the creative thinking skill in mathematics.

Analysis of examples of subject answers with level 3 creative thinking skills is seen in Figure 6.
From the answers to question number 3 on the fifth subject, it shows that student has not been able to show originality in the creative thinking skill in mathematics. Student is still working on the questions in a way that is usually exemplified by the teacher, namely with the concept of linear equations, but student is able to work on questions correctly and fluently on question number 1 and do things differently in question number 2, so that students are able to show indicators of fluency and flexibility in the creative thinking skill in mathematics.

3.2 Discussion

According to table 3 the results of the students’ written tests and the analysis of the answers to the students’ creative thinking skill, most of the subjects were able to show indicators of fluency in the creative thinking skill in mathematics, but there were also subjects who had not been able to show these indicators of fluency. Of the five subjects, it shows that they are at different levels of creative thinking skills in mathematics, there is a student who is at level 0 or not creative at the level of creative thinking skills in mathematics, level 1 or less creative, level 2 or quite creative, and level 3 or creative, but none of the subjects were found to be at level 4 or very creative.

3.2.1 First Subject

In the first subject, the student was able to work on the questions fluently, it’s just that the student’s final answer is not correct. The error may lie in the students’ inability to work on the questions. The first subject student is able to show the correct flow of work in doing the questions, but students start making mistakes when determining \( \text{adj}(A) \) which results in errors in the final result. In question number 2, the first subject was able to solve the problem with the right answer, but the first subject was only able to use one method, namely by using a matrix determinant. This shows that the first subject has not been able to achieve the flexibility indicator in the creative thinking skill in mathematics. It is different with question number 3, the first subject is able to solve questions with answers that are not widely used by other students, the first subject uses the matrix concept to find age comparisons when most students use linear equations to solve it, because of that the students in the first subject fulfill the indicators originality in the creative thinking skill in mathematics.
3.2.2 Second Subject
In the second subject there is also no indicator of fluency in the answer to question number 1. The student in the second subject is not able to work on the questions fluently and correctly. The student immediately answers the questions without any processing, and the answers are also not correct, but the student knows the direction of the answer which is indicated by the student being able to write the inverse matrix symbol correctly \((A^{-1})\). In question number 2, the second subject is not correct in making a matrix form in the question, but the student is able to answer the questions correctly using the method that had been taught in the linear equation material. This shows that students in the second subject have not been able to achieve the flexibility indicator because they only use one method in working on the problem, namely by eliminating and substituting in linear equations. In question number 3, the second subject is able to answer questions correctly, but has not been able to fulfill the originality indicator of the creative thinking skill in mathematics, because the second subject solves problems in a way that is usually used or exemplified in linear equation material.

3.2.3 Third and Fourth subject
Subjects Students in the third and fourth subjects are able to solve the first questions fluently correctly, so that the third and fourth subjects fulfill the fluency indicator of the creative thinking skill in mathematics. In question number 2, the third and fourth subjects both solve the problem in one way, namely by using the determinant of the matrix to find the values for \(x\), \(y\) and \(z\). This shows that students in the third and fourth subjects have not fulfilled the indicator of flexibility in creative thinking skill in mathematics. In question number 3, the third and fourth subjects are not able to fulfill the originality indicator of the creative thinking skill in mathematics, this is because the two subjects solve problems in a way that is usually used by other students in looking for age comparisons, namely by substitution in linear equations.

3.2.4 Fifth Subject
Students in the fifth subject are able to solve the first problem smoothly and correctly, this shows that the first subject is able to meet the fluency indicator of the ability to think creatively in mathematics. In question number 2, students were also able to solve questions correctly and were able to solve questions in more than one way. Students solve problems with the concept of matrices and the concept of linear equations, this shows that students are able to meet the indicators of flexibility in the ability to think creatively in mathematics. In question number 3, students solve the problem in the usual way, namely with the concept of linear equations, this shows that the fifth subject student has not been able to meet the authenticity indicator in the ability to think creatively in mathematics.

From the test results contained in table 3, creative thinking skill tends to be low. This can be seen from only 20% of students who have the ability to think creatively at level 3. This is in line with the research conducted by Rahman in 2020 which was conducted in Bandung Regency, which states that the creative thinking ability of high school students in Bandung Regency is classified as low [22]. The level of creative thinking skill can be improved. One method is to use an appropriate learning model, including the group investigation model [23]. Some of the factors that affect the ability to think creatively are a good learning climate, motivation and intelligence [24].

4. Conclusion and Suggestion
Based on the test results of the creative thinking skill in mathematics, it was found that of the five subjects had varying levels of creative thinking skill in mathematics, from 5 subjects, 1 subject (20%) was unable to show the three indicators of mathematical creative thinking abilities (not creative), 2 subjects (40 %) able to show indicator of fluency (less creative), 1 subject (20%) able to show Originality (creative enough), and 1 subject (20%) able to show indicator of fluency and flexibility (creative). The school environment plays an active role in the process of increasing the level of mathematical thinking. Teachers can also develop students’ creative thinking which will help shape creative situations, support
student initiative, and give place to new and original ideas. Teachers can help students improve their creative thinking skill in mathematics by helping students deepen their understanding of matrix concepts, forming creative situations, supporting student initiatives, and giving place to new and original ideas. Teachers can also give various questions so that students are familiar with various types of questions. Students and teachers can work together in increasing understanding of the concept of matrices so that the creative thinking skill in mathematics in matrix material can develop optimally. This research can be continued by enlarging the population and increasing the number of samples, and use other materials, further researchers can also add interviews as a data collection technique, which may allow other findings to be found.

Reference
[1] Pane A and Darwis Dasopang M, 2017 Belajar Dan Pembelajaran FITRAHJurnal Kaji. Ilmu-ilmu Keislam. 3 333.
[2] Fitriani Y, 2018 Pengaruh Model Pembelajaran Value Clarification Technique Terhadap Karakter Antikorupsi Siswa (Bandung: UPI).
[3] Hamalik O, 2013 Kurikulum dan Pembelajaran Jakarta: Pusat Penerbit PT Bumi Aksara.
[4] Hudoyo H, 2003 Pengembangan Kurikulum dan Pembelajaran Matematika (Malang: UM Press).
[5] Ariesandi S, 2007 Mathematics (Jakarta: PT. Gramedia Pustaka Utama).
[6] Aripin U and Purwasih R, 2017 Penerapan Pembelajaran Berbasis Alternative Solutions Worksheet Untuk Meningkatkan Kemampuan Berpikir Kreatif Matematik J. Pendidik. Mat. FKIP Univ. Muhammadiyah Metro 6 225–233.
[7] McComas W F, 2014 Trends in International Mathematics and Science Study (TIMSS) Lang. Sci. Educ. 108–108.
[8] Depdiknas, 2004 Kurikulum 2004 Standar Kompetensi Mata Pelajaran Matematika Sekolah Menengah Pertama dan Madrasah Tsanawiyah (Jakarta: Depdiknas).
[9] Risnansanti, 2010 Kemampuan berpikir kreatif matematis dan self efficacy terhadap matematika siswa Sekolah Menengah Atas (SMA) dalam pembelajaran inkuiri (Bandung: UPI).
[10] Putra I, 2012 Meningkatkan Kemampuan Berpikir Kreatif Siswa dengan Pembelajaran Berbasis Masalah J. Pendidik. dan Pembelajaran Katulistiwa 5 22–26.
[11] Tambunan E T and Surya E, 2019 Pengaruh Kemampuan Berpikir Kreatif (Creative Thinking) Siswa dalam Menyelesaikan Masalah Matematika J. Univ. Negeri Medan December 1–8.
[12] Reynaldi R and Astuti D, 2016 Kemampuan berpikir kreatif matematis siswa dikaji dari tingkat disposisi matematis di madrasah aliyah J. Pendidik. dan Pembelajaran Katulistiwa 5 1–15.
[13] Pertwii W, 2018 Analisis kemampuan berpikir kritis matematia peserta didik SMK pada materi matris Pend. Tamnusai 2 793–801.
[14] Sugilar H, 2013 Meningkatkan Kemampuan Berpikir Kreatif Dan Disposisi Matematik Siswa Madrasah Tsanawiyah Melalui Pembelajaran Generatif Infin. J. 2 156.
Kreatif Dan Pemecahan Masalah Matematis Siswa Madrasah Aliyah J. Anal. 4 188–198.

[24] Amtiningsih S Dwiastuti S and Puspita Sari D, 2016 Peningkatan Kemampuan Berpikir Kreatif melalui Penerapan Guided Inquiry dipadu Brainstorming pada Materi Pencemaran Air Improving Creative Thinking Ability through Guided Inquiry Combined Brainstorming Application in Material of Water Pollution Proceeding Biol. Educ. Conf. 13 868–872.