ANALYSIS OF STUDENTS' MATHEMATICAL CREATIVE THINKING ABILITY IN TERMS OF COMPLEX NUMBER MATERIAL CLASS XI SMA

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ABSTRAK

Kemampuan berpikir kritis matematis sangat penting dalam seluruh sistem pengajaran dan pembelajaran saat ini. Kemampuan berpikir kritis matematis dalam pembelajaran matematika adalah kemampuan yang seharusnya dimiliki oleh setiap siswa untuk memecahkan masalah matematika. Kemampuan berpikir kritis matematis sangat penting untuk dikembangkan agar siswa dapat menyelesaikan berbagai permasalahan yang semakin berkembang dan kompleks serta berpikir sistematis, khususnya dalam pembelajaran matematika. Penelitian ini bertujuan untuk menganalisis kemampuan berpikir kreatif matematis siswa ditinjau dari materi bilangan kompleks. Penelitian dilakukan SMAN 1 Kajen Kabupaten Pekalongan. Penelitian ini menggunakan kualitatif melalui deskriptif analisis. Subyek penelitian adalah siswa kelas XI sebanyak 30 siswa. Teknik pengumpulan data menggunakan lembar tes, khususnya melalui tes kemampuan berpikir kreatif matematis. Keabsahan data menggunakan triangulasi teknik. Teknik analisis data melalui model Miles, Huberman, dan Saldana yaitu kondensasi data, display data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa siswa mampu mencapai ketuntasan secara klasikal. Ketercapaian setiap indikator kemampuan berpikir kreatif matematis siswa pada materi bilangan imajiner rata-rata mencapai 76,4%. Penelitian ini bermanfaat untuk siswa dan guru sebagai evaluasi dalam pembelajaran matematika, khususnya pada konsep yang abstrak.

Kata kunci : kemampuan berpikir kreatif matematis, bilangan kompleks, pembelajaran matematika

ABSTRACT

Mathematical critical thinking skills are very important in the entire teaching and learning system today. Mathematical critical thinking skills in mathematics learning are abilities that should be possessed by every student to solve mathematical problems. Mathematical critical thinking skills are very important to develop so that students can solve various problems that are increasingly developing and complex and think systematically, especially in learning mathematics. This study aims to analyze students' mathematical creative thinking

ability in terms of complex number material. The research was conducted at SMAN 1 Kajen Pekalongan Regency. This research used qualitative through descriptive analysis. The research subjects were class XI students as many as 30 students. Data collection techniques used test sheets, especially through mathematical creative thinking ability tests. Data validity using triangulation techniques. Data analysis techniques through the Miles, Huberman, and Saldana model, namely data condensation, data display, and conclusion drawing. The results showed that students were able to achieve classical mastery. The achievement of each indicator of students' mathematical creative thinking ability on imaginary number material reached 76,4% on average. This research is useful for students and teachers as an evaluation in learning mathematics, especially on abstract concepts.
Keywords : *mathematical creative thinking ability, complex numbers, mathematics learning*

INTRODUCTION

Education is an educational process carried out by a teacher or teacher to students by providing examples, role models, learning, directing, and improving moral ethics, as well as exploring the knowledge of each individual (Annisa, 2022). The educational process and environment are designed to enable students to actively develop their capacities so that they can gain the spiritual and religious strength, self-control, personality, intelligence, noble morals, and skills needed for themselves and society. Mathematics is a field that studies abstract concepts and symbols, so it is often associated with everyday problems. This allows students to develop their knowledge by discovering mathematical concepts through their own experiences (Dinni, 2018).

Regulation of the Minister of National Education Number 21 of 2016 states that the mastery of mathematics subject matter given to high school students and equivalent aims to equip students with the ability to think critically, logically, creatively, innovatively, and develop students' ability to apply mathematics in solving problems in everyday life. Based on this regulation, it is clear that in learning mathematics, one of which students are expected to have the ability to think creatively.

Creative is having inventiveness or having the ability to create, while mathematical is very certain and precise. Creative thinking skills in mathematics learning can be defined as the ability of students to combine several aspects of an idea and then

combine them into a structured, unique, and new unit. This ability also includes the ability of students to design a variety of solutions to find answers in more than one way or often called “multiple solutions” (Kamalia & Ruli, 2022:240).

One of the goals that need to be achieved in learning mathematics is students' ability to think creatively. Learning mathematics is essential for students' ability to think critically, solve problems, communicate, relate mathematics to the real world, and use technology. This ability allows students to solve math problems in new and innovative ways. This ability can also help students to understand abstract mathematical concepts better.

Creative thinking in mathematics and in other fields is an important part of life skills and needs to be developed especially in the face of the information age and an increasingly competitive atmosphere. Those who have the opportunity to think creatively will grow up healthy and able to face challenges, while those who do not have this opportunity will become frustrated and dissatisfied due to lack of innovation and creativity. Thus, the development of creative thinking skills is an important thing to do and needs to be trained in students starting from the primary education level to the secondary education level.

Students' creative thinking skills cannot develop properly if the teacher does not involve students actively in the learning process including concept formation and the learning methods used in schools are still conventional, namely teacher-centered learning. This learning can hinder the development of students' creativity and activities, such as communication of ideas and concepts. This situation is no longer in accordance with the purpose and objectives of learning mathematics. Learning objectives are achieved when the plans and methods used influence students' potential and abilities, and success occurs when students participate in the thinking process.

In addition, based on the results of research conducted (Pratiwi et al., 2018), it shows that students' mathematical creative thinking skills are still relatively low because students are often not given the opportunity to practice in solving problems that require creative thinking. An overly structured curriculum and tests that focus too much on factual knowledge often do not provide space for the development of

creative thinking skills. So it is important for students to adapt to very rapid changes especially in this day and age.

One of the materials that enrich students' mathematical understanding is complex numbers. Complex numbers are one of the important materials in mathematics that high school students learn in grade XI. This material has many applications in various fields, such as physics, engineering, and computer science. In addition, complex numbers can also be a powerful tool to develop students' mathematical creative thinking skills. Complex numbers are used to understand difficult functions in the real world.

The ability to understand and use complex numbers allows students to solve a variety of more complex mathematical problems, especially those involving negative square roots or calculations in domains involving complex number domains. Complex numbers can seem difficult because the concept involves a deeper understanding of mathematics, especially about imaginary numbers. Students have difficulty in choosing the right formula to solve problems on complex numbers. Therefore, error analysis is needed so that students do not repeat the same mistakes. The material in math is the initial foundation for the next material. If students do not understand the concepts in mathematics material correctly, these students will have difficulty in understanding the concepts in the next mathematics material because the concepts in mathematics lessons are arranged systematically, so in learning mathematics there should be no missed concepts.

This study aims to analyze students' mathematical creative thinking ability, especially in the context of complex number material, at the XI grade high school level. By understanding the level of students' mathematical creative thinking ability, teachers can adjust their teaching approach to provide a more in-depth and satisfying learning experience.

Qualitative research is research that is descriptive and analytical in nature. Descritive in a qualitative approach means describing in describing the events, phenomena and social situations being studied. Analyze means interpreting and comparing research data. According to Creswell in (Murdiyanto, 2020) defines qualitative research as a process of investigasting social phenomena and human problems. Qualitative research is also defined as a strategy to search for meaning,

understanding, concepts, characteristics, symptoms, symbols and descriptions of a phenomenon, focused and multimethod, natural, and holistic in scientific research.

In this study, the subjects studied were students of class XI MIPA SMA N 1 Kajen who received complex number material in advanced mathematics subjects. The number of students who became research subjects was 32 students. The data collection technique used a description test with the type of questions according to the indicators of creative thinking, namely, fluency, flexibility, detail and originality. Data analysis techniques by analyzing answers from student tests by mapping according to creative thinking indicators. In this research, researchers used qualitative descriptive analyze techniques. Research analyze is directed at dinding knowledge or theories regarding previous research through national and internasional journals. Analyze data by classifying, finding similarities and differences, providing insights and combining.

Through this analysis, it is expected to reveal the extent to which students master the basic concepts of complex numbers and the extent to which they are able to apply this knowledge in situations that require creative thinking. The results of this study can provide valuable insights for the development of mathematics curriculum and more effective teaching strategies in high schools.

Based on the description above, the researcher is interested in conducting research related to students' mathematical creative thinking in Complex Numbers class XI SMA Negeri 1 Kajen.

DISCUSSION

1. Math Learning

Mathematics is gobalized field of science. It lives in a real without borders. There is no country that rejects its presence and no religion that forbids the study of it. It doesnt want to be politicized its existence in the world is neede and Its life continues to evolve in line with the demands of humanity's needs, because there is no human activity or behavior can be separated from mathematics. Mathematics haa become the quees as well as the servant of other sciences (Kamarullah, 2017).

School math learning now is very different from math learning in the past. School math learning now develops in line with changes in science and

technology and also based pn changes in the view of the nature of mathematics itself. Changes in view about thenatue of mathematics resulted in also changes to learning theory in learning of school mathematics. At generally the learning theory implemented in school is a modern learning theory. Rusefendi states that teaching and learning theory that is used in modern learning is mixture of linking theory from Thondike, the floor of developmental psychology such as Piaget, as well as the flow of behavior from skinner and gagne. But the more dominant theory used is the developmentap psychology and constructivism because at the center of teaching mathematics is problem solving.

Mathematics learning in Indonesia according to (Simanungkalit et al., 2013) has clear goal which is to form the ability to reason in student which is reflected through the ability to think critically, logically, and analytically and systematically. In addition to learning theory, learning methods in learning school mathematics today is also changing. Learning methods conbentional or tradisional learning methods used to change to the methods of discovery, problem solving, CTL, scientific approach this is in line with the demands of the school mathematics curriculum in 2013. This 2013 curriculum is a curriculum education unit level based on scientific, ao that the most proved thing is student higher order thinking skills. By applying the above learning methods, then learning will be more meaningful so that it will help student understanding.

2. Complex Number

Complex numbers are an extension of the real number system, which facilitates solving equations that do not have solutions in the real domain. These numbers are represented with the symbol z.

The general form of complex numbers is written as $\boldsymbol{z = x + iy.}$

The complex numbers $z = x + iy$, include:

a. Real numbers $Re(z) \neq 0$ and imaginary numbers $Im(z) = 0$ so $z = x$ is a real number. Thus, all real numbers x can be viewed as complex numbers with the form $z = x + 0iy$.
b. The real number $Re(z) = 0$ and the imaginary number $Im(z) \neq 0$ then $z = iy$ is an imaginary number.

c. The real number $Re(z) = 0$ and $Im(z) = 1$ then $z = iy$ is called an imaginary unit.
d. The real number is zero and the imaginary number is zero then it is said to be a zero complex number or $z = 0$ so $z = 0 = 0 + 0i$

Example:

a. $3 + 2i$ is a complex number with real part 3 and imaginary part 2.
b. $-4 - 5i$ is a complex number with a real part of -4 and an imaginary part of -5.
c. $1\ i$ is a complex number with real part 0 and imaginary part 1.

Complex numbers can be visualized in the complex plane, which is a two-dimensional coordinate system. In this system, the real component of the number is represented by the x-axis while the imaginary component is represented on the y axis.

Each complex number $z = x + iy$ is plotted as a point on the complex plane with coordinates (x, y).

Algebra on complex numbers with algebraic operations that include uner operations and binary operations and the properties of operations as follows:

a. Unary operation
   1) Negative ⟶ (opposite of addition) of complex numbers
      $z = x + iy$
      Definition: $-z = -(x + iy) = -x - iy$
   2) Conjugate of a complex number $z = x + iy$
      Definition: $\bar{z} = x - iy$, so that $z = x + iy$ and $\bar{z} = x - iy$
   3) The inverse ⟶ (opposite multiplication) of a complex number
      Definition: $\frac{1}{z} = z^{-1} = \frac{x}{x^2+y^2} - i\frac{y}{x^2+y^2}$

b. Binary Operation

If $z_1 = x_1 + iy_1$ and $z_2 = x_2 + iy_2$ then:

1) $z_1 + z_2 = (x_1 + iy_1) + (x_2 + iy_z) = (x_1 + x_2) + i(y_1 + y_2)$

2) $z_1 - z_2 = (x_1 + iy_1) - (x_2 + iy_z) = (x_1 - x_2) + i(y_1 - y_2)$

3) $z_1 z_2 = (x_1 + iy_1)(x_2 + iy_z) = (x_1 x_2 - y_1 y_2) + i(x_1 y_2 + y_1 x_2)$

4) $\frac{z_1}{z_2} = \frac{x_1 x_2 + y_1 y_2}{x_2^2 + y_2^2} + i\frac{y_1 x_2 - x_1 y_2}{x_2^2 + y_2^2}$ with terms $z_2 \neq 0$

(Retno Marsitin, 2017)

3. Students' Mathematical Creative Thinking

Creative thinking ability in mathematics refers to the capacity of students to generate novel and innovative solutions when tackling mathematical problems. This involves more than just memorizing formulas or solving problems at speed, it also requires a deep understanding of mathematical principles and the ability to apply them in a variety of contexts. Mathematical creative thinking has been an important area of research for mathematics education experts for decades. They have defined, explored and analyzed the various dimensions of creative thinking in this area and have developed strategies aimed at enhancing this capability in students.

Mathematical creative thinking is the process of thinking to: multiply possibilities, delay consideration, provide new and unusual possibilities, use imagination and intuition, develop and choose alternatives, and have many ways and use different points of view or answers to something. Mathematical creative thinking is also an ability to think creatively to produce new solutions in varied answers to mathematical problems more easily.

With mathematical creative thinking, students can have the ability to produce varied solutions that are new to open-ended mathematical problems. From this explanation, it can be concluded that students' mathematical creative thinking has several important components, namely:

a. The ability to generate new and innovative solutions.
b. The ability to see problems from various points of view.
c. The ability to think flexibly and not stick to one way.
d. The ability to use imagination and intuition.

e. Ability to develop and select alternatives.
f. Ability to cooperate with others.

Characteristics of Mathematically Creative Thinking Students

a. Problem Solving Ability: Students are able to solve math problems in various ways, not just sticking to one method.
b. Pattern Finding Ability: Students are able to see patterns and relationships in mathematical data and concepts.
c. Critical Thinking Ability: Students are able to analyze information and come up with new ideas in a logical and structured manner.
d. Mathematical Communication Skills: Students are able to explain their mathematical ideas clearly and effectively, both orally and in writing.
e. Ability to Cooperate: Students are able to work together with a team to solve complex mathematical problems.

Indicators of Mathematical Creative Thinking

a. Fluency

   Fluency in generating ideas is considered a key indicator of creative thinking ability. This ability shows how a person can come up with many ideas, which increases the chances of getting significant and innovative ideas.

b. Flexibility

   This characteristic describes the mental adaptive capacity of an individual in responding to changing situations, or the ability to immediately see a problem from a variety of different perspectives. Flexibility includes the skill of navigating mental barriers and adapting approaches to problems without being bound by assumptions of rules or conditions that are not relevant to the situation.

c. Elaboration

   Elaboration can be defined as the ability to explain in detail about an object. The main function of elaboration is as a connector that allows one to convey their creative ideas to a wide audience. This aspect is an important determinant in assessing the success of an idea when presented

to others. Elaboration is realized through the addition of information and details that enrich a basic concept, thus making it more complex and profound.

d. Originality

Originality is a marker of uniqueness in any given response. Responses that are considered original tend to be characterized as unusual, unique, and rare. Thinking about the future can often lead to innovative ideas. Questions designed to assess this ability generally demand the creative use of everyday objects.

4. Analysis of Students' Mathematical Creative Thinking in Solving Complex Number Problems

Based on the results of the mathematical creative thinking ability test, the percentage of each indicator is obtained which refers to the scoring criteria according to (Suparman & Zanthy, 2019) presented in the table below.

Table 1. Percentage of Mathematical Creative Thinking Ability Indicators

Indicator	Fluency	Flexibility	Originality	Elaboration
Percentage	89,6%	85,9%	68,3%	61,8%

Table 1 shows that the percentage of mathematical creative thinking ability in the fluent thinking and flexible thinking indicators is 89,6% and 85,9% while the original thinking and detailed thinking indicators are 68,3% and 61,8%. Then two indicators with the lowest percentage were selected, namely the original thinking and detailed thinking indicators, from each indicator two samples of student answers were taken for analysis.

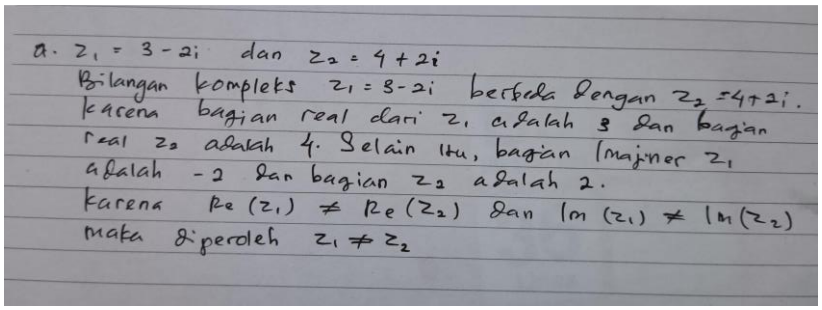
Analysis of Originality Thinking Indicators

Questions

Determine if each of the following complex numbers is equal or different $z_1 = 3 - 2i$ and $z_2 = 4 + 2i$

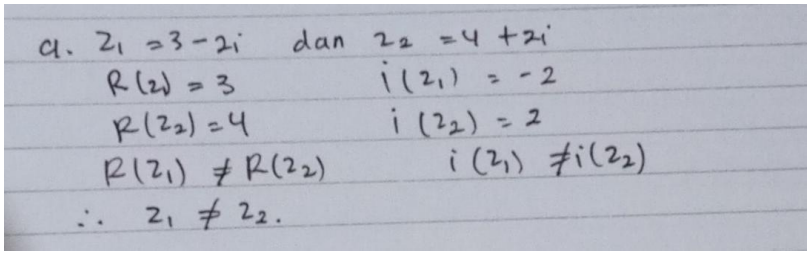
Answer

- Student answer 1



Picture 1. Student answer 1

- Student answer 2



Picture 2. Student answer 2

In figures 1 and 2, it can be seen that students are able to provide answers or solutions that are different from common answers or those that are usually taught in class. They are willing to take risks and try new ideas, even though they may not necessarily work. Students are able to see connections between different mathematical concepts and use them to solve problems. They are not fixated on one particular mathematical concept, but are able to see the connection with other concepts.

The answer of the second student has fulfilled the characteristics of original thinking.

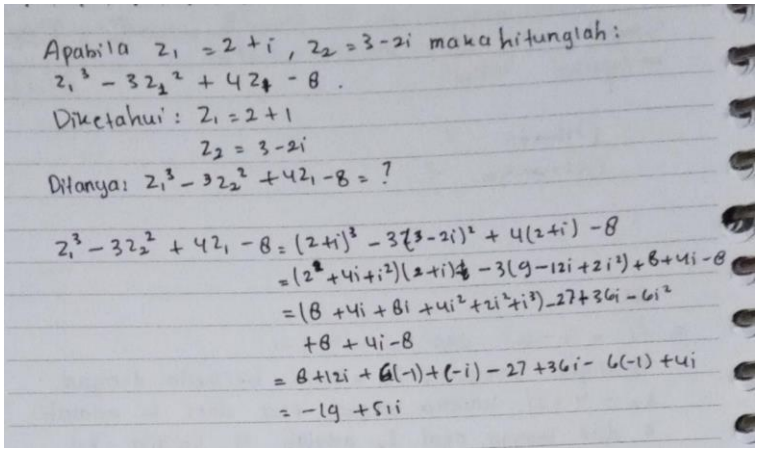
Analysis of Elaboration Thinking Indicators

Question

If $z_1 = 2 + i, z_2 = 3 - 2i$ then calculate ${z_1}^3 - 3{z_2}^3 + 4z_1 - 8$

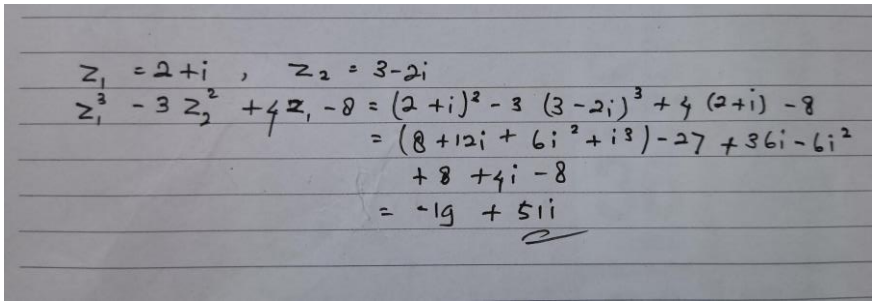
Answer

- Student answer 3



Picture 3. Student answer 3

- Student answer 4



Picture 4. Student answer 4

In Figure 1 and 2, it can be seen that students are able to explain their mathematical ideas clearly and in detail. Students are able to explain their mathematical ideas using language that is easily understood by others. Their explanations show a deep understanding of the underlying mathematical concepts. They were able to use logical reasoning and mathematical evidence to support their ideas. This ability shows that they have a strong understanding of the underlying mathematical concepts.

The answer of the third student has fulfilled the characteristics of detailed thinking.

CONCLUSION

Based on the data analysis that has been done, the lowest percentage of creative thinking ability indicators is the ability to think original at 68.3% and the ability to think in detail at 61.8%. The level of students' creative thinking ability is at a moderate level as seen from the small number of students' answers that are wrong or incorrect in answering questions. Then student errors in solving mathematical creative thinking ability problems lie in the process of making mathematical models, identifying the adequacy of elements and concepts contained, and errors in arithmetic operations. It is hoped that this research can be used as a reference material and reference for future research.

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