ANALYSIS OF STUDENTS' CREATIVE MATHEMATICAL THINKING ABILITY IN SOLVING COMPLEX NUMBERS IN COMPLEX ANALYSIS COURSES BASED ON ACADEMIC ABILITY LEVEL

Risnawati[1], Efa Wafiq Azizah[2], Ilham Maulana Syaputra[3]
Tadris Mathematics UIN KH Abdurrahman Wahid Pekalongan
risnawati@mhs.uingusdur.ac.id , @mhs.uingusdur.ac.id , @mhs.uingusdur.ac.id

ABSTRAK

Mahasiswa memerlukan kemampuan berpikir matematis dan kreatif ketika mengikuti perkuliahan analisis kompleks. Tujuan penelitian ini adalah untuk menganalisis kemampuan berpikir matematis dan kreatif mahasiswa ketika menyelesaikan masalah bilangan kompleks pada mata kuliah analisis kompleks, dengan memperhatikan tingkat kemampuan akademiknya. Metode penelitian yang digunakan adalah penelitian kualitatif dengan pendekatan deskriptif. Partisipan penelitian adalah mahasiswa semester 6 tahun ajaran 2023/2024 program studi Tadris Matematika K.H. Universitas Abdurrahaman Wahid Pekalongan yang berjumlah 30 orang. Subyek penelitiannya adalah kemampuan berpikir matematis dan kreatif siswa pada mata kuliah analisis kompleks. Hasil analisis menunjukkan terdapat perbedaan kemampuan berpikir kreatif matematika siswa ketika menyelesaikan permasalahan bilangan kompleks. Siswa dengan kemampuan akademik yang lebih tinggi cenderung mempunyai strategi pemecahan masalah yang lebih baik, lebih kompleks dan fleksibel. Di sisi lain, siswa dengan kemampuan akademik rendah cenderung mengalami kesulitan dalam menerapkan konsep matematika yang relevan. Hasil tersebut menunjukkan pentingnya mendukung pengembangan kemampuan berpikir kreatif matematis siswa khususnya pada konteks bilangan kompleks. Implikasi dari penelitian ini dapat dijadikan landasan bagi lembaga pendidikan untuk mengembangkan strategi pembelajaran yang lebih efektif dan komprehensif untuk meningkatkan kemampuan berpikir matematis dan kreatif siswa pada berbagai tingkat kemampuan akademik.

Kata Kunci: bilangan kompleks, kemampuan berpikir matematis, tingkat kemampuan akademik

ABSTRACT

Students need the ability to think mathematically and creatively when following their eyes complex analysis lecture. The purpose of this research is to analyze students' mathematical and creative thinking abilities when solving complex number problems in complex analysis courses, taking into account the level of academic ability. The research method used is qualitative research with a descriptive approach. Research participants were students in the 6th semester of the 2023/2024 academic year of the Tadris study program Mathematics at K.H. Abdurrahaman Wahid University Pekalongan, totaling 30 people. Subject the

research is students' mathematical and creative thinking abilities in courses complex analysis. The results of the analysis show that there are differences in creative thinking abilities of mathematical students when solving complex number problems. Students with Higher academic abilities tend to have better problem solving strategies, more complex and flexible. On the other hand, students with low academic abilities tend to experience difficulty in applying relevant mathematical concepts. These results show the importance of supporting the development of mathematical creative thinking abilities students, especially in the context of complex numbers. The implications of this research can be made foundation for educational institutions to develop more effective and comprehensive learning strategies to improve students' mathematical and creative thinking abilities at various levels of academic ability.
***Keywords**: Complex numbers, mathematical thinking ability, level of academic ability*

INTRODUCTION

Minister of National Education Regulation no. 41 of 2007 concerning Process Standards states that the learning process in educational units is interactive, must be inspiring, fun, challenging and motivate students to participate actively, and must encourage individual initiative and independence in accordance with their talents, concerns and physical and psychological development of students.

Process standards mandate that learning occurs by providing space for students to be creative. One of the objectives of teaching mathematics mentioned in the 2006 Curriculum is to develop creative activities that involve students. The curriculum indirectly emphasizes the importance of increasing students' creativity and creative thinking abilities when learning mathematics.

Johnson & Johnson (2010) argue that creative thinking is a habit of thinking that is trained by paying attention to intuition, which stimulates the imagination, reveals new possibilities, and opens up surprising perspectives.

In addition, Alvino (Sumarmo, 2010) states that creative thinking includes the following elements: fluency, flexibility, reliability (originality), and elaboration. When students are given the confidence to learn and think independently and have the courage to put forward new ideas in a non-authoritarian atmosphere, their creative thinking abilities will develop.

Vygotsky intended that mathematics classes foster creative thinking, encourage higher-order thinking through cooperative learning, and allow students

to interact with each other and develop effective problem-solving strategies and emphasize scaffolding learning.

Arends and Kilcher (2010) argue that creative thinking is a very interesting type of thinking that is associated with cognitive abilities and the ability to find new solutions to problems. This shows that developing creative thinking skills is very important in mathematics education. Students who are mathematically creative can organize their mathematical thinking using the Learning Process.

Basically, every human being has creative potential, but the question is how to develop this potential during the learning process that takes place in the classroom. One of the problems identified in the Education Review is that thinking skills have not been achieved and are optimal. In fact, one of the most important roles is how people combine thinking abilities and skills.

Therefore, thinking skills should be trained from an early age so that they do not encounter developmental obstacles during learning. For example, Pehkonen, Naveri, and Laine (2014) argue that solutions to problems must be provided by school mathematics.

Based on this opinion, the ability to think creatively in mathematics is a skill that includes four aspects. namely (a) fluency; Demonstrates students' ability to provide many ideas and correct answers to solve problems. (b) flexibility, namely the student's ability to solve a problem in one way and use it in another way; (c) originality, students' ability to solve problems in their own way; (d) elaboration, namely the ability to solve problems by carrying out detailed steps; Square Roots of Complex Numbers is one of the discussions in the Complex Analysis course.

Regarding the roots and powers of complex numbers, advanced knowledge is required to determine the roots of complex numbers and the arguments of complex numbers. This material is very demanding and expects students to have skills and creative thinking skills in the discovery and operational process before finding the final result.

One of the basic concepts underlying this theoretical work is the application of De'Movre's formula and Euler's theorem. At this time, cognitive conflict does not prevent students from being forced to think creatively to find solutions to problem solving. Nurina and Retnawati (2015) found that students at a higher level

of thinking tend to use logic rather than just memorizing and memorizing formulas, thereby improving their mastery of concepts and helping students learn more complex mathematics. problem. The high expectation from the instructor is that students can use their creativity to solve problems and apply the formula. This means that if students use core concepts from other courses, the solutions they receive may be different. In the next step, the basic concept of square roots of complex numbers can be applied to prove analytical functions and harmonic functions. This aims to shape students' mental patterns so they are used to solving mathematical problems.

This research adopts a descriptive and qualitative approach. The data listed are the mathematical and creative thinking abilities of 6th semester students in solving the square roots of complex equations according to their academic level. The location of this research was carried out at the KH Abdurrahman Wahid State Islamic University Pekalongan 2024. The research implementation period started from March to May 2024. The subjects of this research were students in the 6th semester of the 2024 academic year of the KH Abdurrahman Wahid Pekalongan State Islamic University Mathematics Education Program. totaling 30 people. Subjects were divided into three groups based on their academic abilities: students with low academic abilities (8 students), students with medium academic abilities (12 students), and students with high academic abilities (10 students). The choice of topic depends on the research needs.

The research subject is the mathematical creative thinking ability of students in the "Complex Analysis" course from the teaching materials for square roots of complex equations at the KH Abdurrahman Wahid State Islamic University Pekalongan. Data on mathematical creative thinking skills for as many people as possible was collected using test and interview techniques for 30 people. Tests were carried out on all students included in the study. During this time, interviews were conducted with representatives from each category of student performance. This refers to the researcher's limitations in collecting data from certain aspects and time requirements, making it impossible to interview all subjects. The instruments used for data collection in this research were test data and non-test data. The creative thinking ability tool used in this study consisted of a series of tests in the form of

essays. The purpose of this test is to assess students' creative thinking abilities in solving complex analytical problems, especially roots and powers of complex equations. This test instrument is based on a grid of questions referring to the 2013 Curriculum Standards and has four question elements with identified indicators:

1) language proficiency; Ability to provide lots of ideas and, solve problems with the right answers.
2) Flexibility, namely the ability to solve problems in one way and apply another way.
3) Originality is the ability to solve problems in one's own way.
4) Elaboration, namely the ability to solve problems by taking detailed steps.

In this research, a non-examination instrument in the form of an interview form was used to assist data in identifying further information regarding potential barriers.

DISCUSSION

Data on students' creative mathematical thinking abilities is measured through creative thinking tests based on academic ability levels, providing information on the percentage and number of students who give correct and incorrect answers. The results of the student response test on the creative thinking abilities of Mathematics students at the State Islamic University of KH Abdurrahman Wahid can be seen in Table 1.

Table 1. Students' Mathematical Creative Thinking Ability Based on Indicator determined and Academic Ability Level

Level Academic	**Indicator Thinking Ability Creative Mathematical**							
	1		**2**		**3**		**4**	
	B	**S**	**B**	**S**	**B**	**S**	**B**	**S**
Tall	7	9	3	15	7	8	7	5
Currently	4	7	0	10	3	9	9	5
Low	1	2	0	2	1	2	3	1
Amount	12	18	3	27	11	19	19	11

Information:

B: Answer Correct

S: Answer Wrong

Based on Table 1, it can be seen that in indicator 4 (Elaboration) the number of students who answered correctly was the highest, namely 19 . Meanwhile, for indicator 2 (Flexibility) , the number of students who answered correctly was at least 2 . Data shows that students are able to solve problems using detailed instructions.

This means that students are able to solve problems by following the necessary steps even though the method used is long. This also shows that students are accustomed to paying attention to how to solve problems, which is usually taught by teachers with the concept that the problem that needs to be solved needs to be understood in terms of the steps to solving it. Apart from that, it can be said that students are not able to solve problems in one way and then use other methods flexibly (flexibility). This is proven by the majority of students still focusing on superficial knowledge when solving problems.

The learning results from students show that they do not understand or have forgotten the definition of i itself and almost all students lose knowledge at this step, so the solution is only limited to factorization. This figure can be seen from examples of student work in Figure 1. Second, most students have not mastered indicators 1 and 3 fluently and have not been creative in solving questions. This means that the majority of students are still not able to put forward many of the ideas they want to convey so that the results are still limited in solving problems and have not achieved the desired goals. Regarding the third indicator, students are still stuck in routine methods and are not able to solve problems in their own way.

Example 1 is a question with the subject of roots and exponents which measures the ability to think creatively mathematically for the aspects of originality (authenticity), flexibility (fluency).

Example 1

Complex numbers $z = \left(\frac{1+i}{1-i}\right)^3$ can be expressed in the form $a + bi$where a, b are real numbers. The value of ab is equal to...

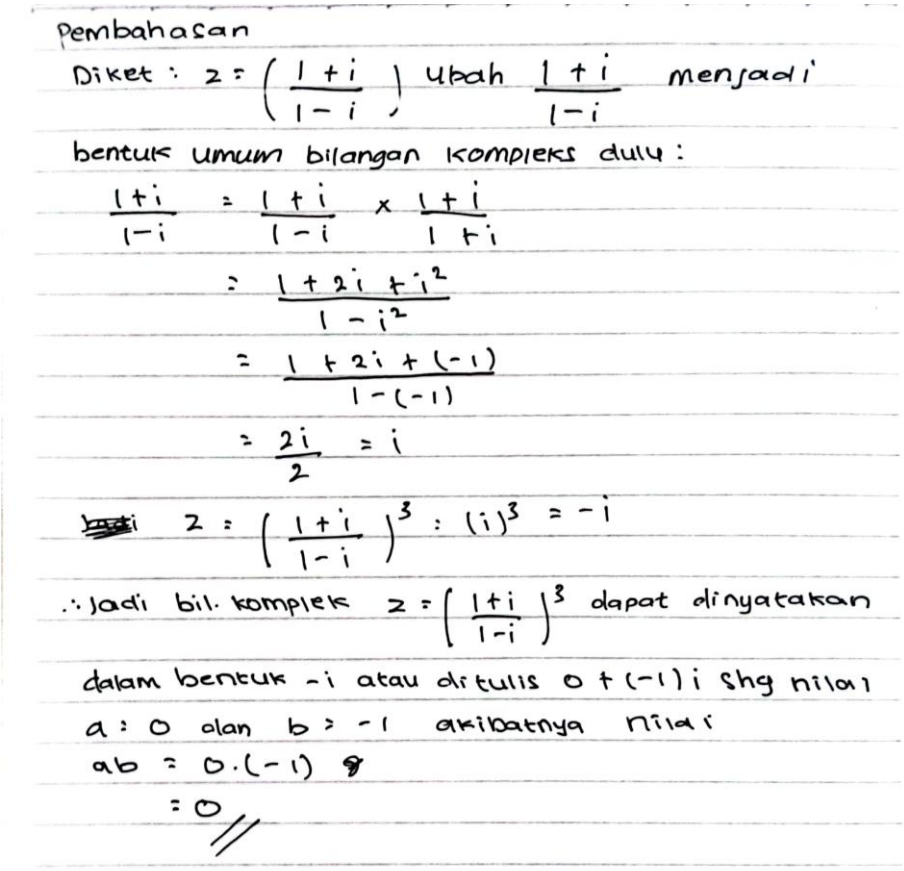

Figure 1. Example Completion question no 1 (indicators 1 and 2)

In the example of question 1, the researcher obtained information that it was true that students were unable to solve the question correctly, this was because:

1. This student does not understand what the polar shape that is being asked is like.
2. This student only separated the fractions.
3. Don't pay attention to deeper matters.
4. Afraid in determine formula .

The following example 2 is adopted from S. Suripah, Aulia Sthephani (2017) which is a question with the subject of roots and exponents which measures mathematical creative thinking abilities for the Originality aspect.

Example 2

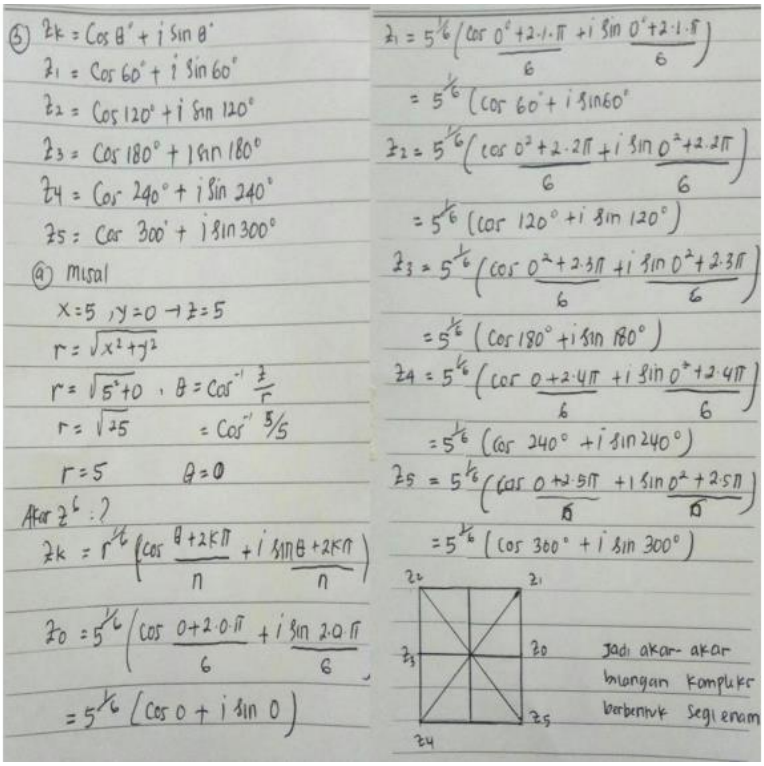

Figure 2. Example solution question no 2 (indicator 3)

Figure 2 can is known that from answer question number 2 analysis complexon There is around 11 student answer with Good. Then For Overall, students made the biggest mistakes in completing or analyzing the form of complex analysis question number 3 is more about the type of error principle, Because in the question number 3 the student not enough thorough in simplify form letter And error from answer student This almost everything focus to simplify form letter No Which other. If students are more careful in reading and studying question number 3, so they can answer question the with easy.

Example 3 is a question with the topic of roots and exponents which measures mathematical creative thinking abilities for the elaboration aspect

Example 3

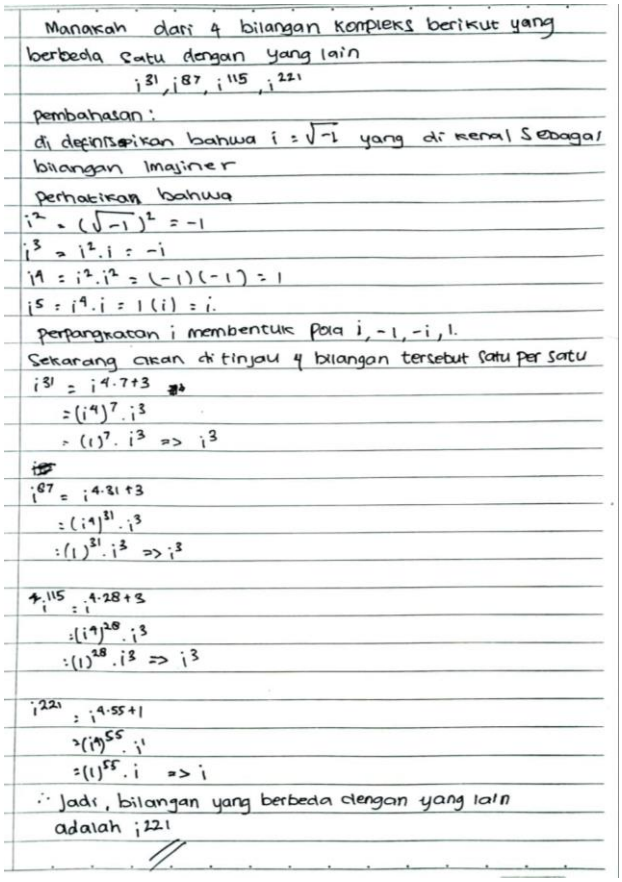

Figure 3. Example solution question no 3 (indicator 4)

It can be seen that from the answer to question number 4 of the complex analysis above there are around 1 9 students answered well. It was found that there were very few students who answered the questions, then overall the students who made the biggest mistakes were in elaborating or analyzing the form of complex analysis question number 4. Thus the researcher saw that the majority of students' answers were able to carry out elaboration, this indicates that the students had able to solve problems by carrying out detailed steps, as shown in the example solution in Figure.

Data Analysis of Students with High Abilities

Students with high academic abilities have the ability to generate lots of ideas and solve problems. However, some of them have not been able to produce the right answer because they are not careful in building solutions through arithmetic operations. Apart from that, they are not able to solve problems in various ways, and sometimes use inappropriate concepts even though they are able to solve

problems in their own way. Even though some students were able to solve the problem with detailed steps, some of them still made mistakes in their proof efforts.

Data Analysis of Students with Medium Ability

For students with moderate academic abilities, it can be seen that they are able to generate many ideas and solve problems. However, some of them were still unable to produce the right answer because they were not careful in determining the value of θ. They also haven't been able to solve the problem in various ways, and the final result is still wrong. Apart from that, they have not been able to solve problems in their own way, as indicated by the fact that many of the answers are relatively the same. Even though some students are able to solve problems with detailed steps, there are still some who are not quite right in this matter.

Data Analysis of Students with High Abilities

For students with low academic abilities, it can be concluded that they have not been able to generate many ideas and solve problems effectively. Even though they have tried to do it, the results are still not right because they don't understand the material. They also haven't been able to solve the problem in one correct way, and there are some who don't even answer. In addition, they have not been able to solve problems according to their own approach, even in other ways. Their ability to prepare detailed steps is also still lacking.

Based on the results of interviews with students randomly taken according to the error indicators, it was found that the factors causing student errors were that some students forgot and made mistakes in understanding the questions. This happens because they never repeat the material that has been taught. Then there was an error in the calculation process. The reason is because some students do not check their answers again and the students already feel confident in their answers. Students do not rewrite known elements, because students are used to answering questions directly without writing down known elemen.

Complex numbers are basically a combination of real numbers and imaginary numbers. The form of a complex number is a+ib, where a = real number and ib = imaginary number. Furthermore, a, b are real numbers and i = √-1.

To solve the equation x 2 +1 = 0, complex numbers are introduced. The roots of the equation are of the form x = ±√-1, and there are no actual roots. Therefore,

the introduction of complex numbers results in imaginary roots. Represents √-1 with the symbol ``i'' which stands for iota (imaginary number).

Therefore, a complex number is simply the addition of two numbers: a real number and an imaginary number. One part is purely real and the other part is purely imaginary. All numbers in the number system, such as positive, negative, zero, whole numbers, rational numbers, irrational numbers, and fractions, are real numbers. This is represented as R. Examples: 12, -45, 0, 1/7, 2.8, √5, etc. are all real numbers.

Unreal numbers are imaginary numbers. If an imaginary number is squared, the result is negative. This is expressed as I. Example: √-2, √-7, √-11 are all imaginary numbers

In mathematics, complex analysis (English: complex analysis), is a branch of mathematical analysis that discusses the function of complex numbers (i.e. studying not just one number, but two numbers, namely a real number and an imaginary number. Complex analysis is a key concept in algorithm development Efficient complex analysis is usually known as complex variable function theory or complex variable function theory. In the world of computing, where time and computing resources are precious, it is very important to have a good understanding of how algorithms behave at different scales The complexity of finding efficient algorithmic solutions should not be ignored, as it can help identify the best algorithm to solve a particular problem in the most efficient way.

Role and Examples of the Importance of Complex Analysis

Complex analysis allows us to understand the performance of complex numbers in a measurable and predictable way. When we talk about the performance of complex numbers, we are often interested in two main aspects: execution time and resource usage. Complex analysis helps us understand how an algorithm's execution time will change with the size of its input (scale), as well as how the use of memory and other computing resources will evolve.

Finding Efficient Solutions with Complex Analysis

1. Identification of problems

   The first stage in this process is to identify the problem at hand clearly and specifically. This is done to ensure a deep understanding of the nature of the problem and the objectives to be achieved.

2. Algorithm Design

   Once the problem is identified, the next step is to design the right algorithm to solve the problem. The design of these algorithms must consider aspects such as efficiency, speed, and readability.

3. Algorithm Complexity Analysis

   To evaluate the performance of the designed algorithm, algorithm complexity analysis is necessary. This involves researching how many resources are required, such as time and space, when the algorithm is run.

4. Optimization:

   Complexity analysis shows that the algorithm is inefficient, an optimization stage is required. This involves adjusting the algorithm or using techniques such as data structure optimization to improve its performance. The goal is to achieve a more efficient and implementable solution.

Complex analysis has become a very important tool in the development of efficient algorithms, especially in the context of complex number processing. By understanding the properties and performance of complex numbers through complex analysis, we can better design and optimize algorithms, thereby increasing the efficiency and performance of computing systems.

CONCLUSION

Based on the results of the research, discussion and analysis that have been explained, it can be concluded that in mathematics education, complex analysis plays an important role in preparing efficient complex number solutions, namely by understanding the time and space complexity of algorithms, researchers can develop complex numbers that are more efficient for solving various problems. math problems.

Based on the results of the research, discussion and analysis described, it can be concluded that: Mathematically creative thinking Students with high academic abilities can find solutions to questions regarding all indicators. Students with moderate academic abilities are able to identify problem solutions based on indicators of fluency and sophistication, but still have relatively the same response on indicators of flexibility and originality. Meanwhile, of the 4. students who had low academic abilities, only those who were able to identify knowledge were limited to measures of originality and sophistication, and inaccurate on both fluency and flexibility measures.

REFERENCE

Arends, R.I., & Kilcher, A. (2010). Teaching for student learning: becoming an accomplished teacher.

New York: Routledge. Conklin, W. (2012). Higher-order thinking skills to develop 21st century learners.

Huntington Beach: Shell Educational Publishing, Inc. Ministry of National Education. (2007). Regulation of the Minister of National Education of the Republic of Indonesia number 41, 2007 concerning process standards for Primary and Secondary Education units.

Griffin, P., McGaw, B., & Care, E. (Eds). (2012). Assessment and teaching of 21st skills. New York, NY: Springer Publishing Company.

Haylock, D. (1997). Recognizing mathematical creativity in school children. ZDM 29(3), 68-74.

Johnson, D. W., & Johnson, R. T. (2010). Collaborative learning. learning strategies for mutual success. (Translated by Narulita Yusron). Bandung: Nusa Media. (The original book was published in 2004).

Kaufman, Plucker & Baer. (2008). Essentials of creativity assessment. John Wiley. Krutetskii, V. A (1976). The psychology of mathematical abilities in school children.

Chicago: University of Chicago Press. Munandar, U. (2002). Blessing creativity. strategy to realize creative potential and talent. Jakarta: PT Gramedia Pustaka Utama.

Nur, SH (2011). The ability to think creatively mathematically and learn mathematics based on open ended problems. Journal of Mathematics Education 5(1), 104-111.

Nurina, D., & Retnawati, H. (2015). The effectiveness of learning using the problem posing approach and the open ended approach is reviewed from HOTS.