Analysis of mathematical creativity in mathematics learning is open ended

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Analysis of mathematical creativity in mathematics learning is open ended

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Abstract. The ability of mathematical creativity is needed by every mathematics education student. Mathematical creativity is an important part of Mathematics education. But the mathematical creativity of most Mathematics Education students is still low. Therefore, mathematical creativity is needed for students in Mathematics Education, especially for students who are studying Real Analysis courses. Based on the results of the Open-Ended Real Analysis course, it can be seen the quality of the students' mathematical creativity. The purpose of this study is to analyze the location, causes, and types of student errors in doing Open-Ended Real Analysis test questions through the use of the Newman Error Analysis (NEA) medium. Newman Error Analysis includes Reading Error, Comprehension Error, Error Transformation, Skill Error Process, and Encoding Error. This research is a type of qualitative research. The subjects of this study were students taking Real Analysis courses in the Mathematics Education Study Program at Pancasakti University, Tegal Indonesia. The research subjects were 64 students. The results showed that students in doing the Open-Ended Real Analysis test questions were still confused using the theorem that was right to use. It means that students in the transformation process discuss problems and the skill process is still lacking. This is by the five types of errors / Newman Error Analysis described by experts in Mathematics Education. The new findings in this study are errors of carelessness not working on problems, and misconceptions.

1. Introduction

Every student in learning is needed for creativity. Likewise, the most important creativity in mathematics is the ability to think creatively. Because thinking is the greatest activity in learning mathematics. According to ([1], [2], [3], & [4])said that creative thinking in mathematics is a combination of divergent thinking and logical thinking that underlies intuition but in an awareness that pays attention to fluency, flexibility, and Originally in the mathematical domain. Whereas according to [4], Mathematical creativity is defined as domain-specific characteristics, allowing individuals to be characterized by fluency, flexibility, and originality in the mathematical domain.

According to [5] said that From an early age in teaching mathematics it is necessary to grow creative characters so that the creative character process will grow. Every student who excels in learning usually has creativity. Likewise, mathematics education students need to be creative in learning. However, most mathematics education students have low creativity. This means mathematical creativity has not been well developed in the field. [6] said that Mathematical creativity plays a very important role in the growth of mathematics as a whole. According to ([4],[7],) between

creativity has a positive relationship with mathematical ability. Mathematical ability is a multi-dimensional construction that includes quantitative ability, causal ability, spatial ability, and spatial rotation ability, qualitative ability and inductive/deductive ability. According to [8] said that students who have high mathematical abilities do not have problems relating to aspects of fluency, flexibility, and originality, except in the aspect of elaboration. likewise according to [9] said that Centered on creativity, so that interaction can be created between mathematics achievement in schools with general talent. According to [10] said that students who have talent in mathematics can be found a relationship of mathematical creativity with mathematical achievement.

Most students have a low level of creative thinking. The factors that affect the weakness of students 'mathematical creative thinking ability are caused by the lack of training or exploring students' thinking abilities. Likewise what happens to students of Mathematics Education do not think to the root of the problem (think fast), have a level of curiosity that is mediocre to solve creative thinking problems so that in providing simple answers by the request of the problem. Therefore according to [11] said that the concept of creativity in learning mathematics needs to be addressed and developed directly during education both in schools and colleges. Likewise, [12] said that If students are given a creativity test it will bring up the characteristics of mathematical talent. Then according to ([13] & [14])said that, if students are allowed to practice their thinking skills, a habit will be formed to be able to distinguish between true and untrue, guesses and reality, facts and opinions, as well as knowledge and beliefs.

According to [15] said that creative thinking is an idea construction process that emphasizes aspects of fluency, flexibility, novelty, and detail. Fluency can be identified from the number of relevant student responses. From the responses of these students can still be categorized into several categories where this is related to the flexibility aspect. There is a possibility that the responses given by students are many but it is only one impression. The student response is said to be authentic (novelty) if it is unique, unusual, and is only done by very few students. The response is said to be detailed if the procedure is coherent, logical, clear, and reasoned.

According to [16] said that Mathematical creativity is one of the most important aspects of solving problems in mathematics. Mathematics education students have mathematical creativity problems in almost every course, one of them in the Real Analysis course. The problem that is mostly found in the Real Analysis course is Sequences and Series material. ([17],[[18]) said that This Sequences and Series material proves convergent sequence. To prove the convergence sequence there are 15 theorems. Students can master well when explained each of the theorems. However, during the sequence test, students were confused about working on the problem, namely in determining the correct theorem used to solve the problem.

According to ([19] & [20]) said that, to foster mathematical creativity in students one of the students is trained to solve questions that fall into the higher-order thinking category. Likewise, according to [21] said that the ability to think creatively is needed in overcoming problem-solving situations, such as when students face questions that are of a high-level thinking category. Open-ended questions are categorized as high-level thinking, Likewise the rank-and-file questions in the Real Analysis course. In this study, students were given exam questions for Sequences and Series material based on open-ended. The use of these questions so students can think optimally. From the answers of this exam, the location and causes of students' mistakes in answering the exam questions will be found.

Real Analysis is a subject that is considered very difficult for students of mathematics education. One of them is because the Real Analysis discusses many proofs of theorems and problems that require high analytical thinking, ([17] & [18]). Meanwhile, during lectures students do not have much contact with the process of analyzing theorems or constructing arguments using the theorems in mathematics. Therefore, to reveal the location and type of errors of students in working on the Open-Ended Real Analysis test.

The location and causes of student errors in working on Real Analysis problems have been extensively studied by experts in Mathematics Education. However, this research will find the location and type of errors in students in doing the Open-Ended Real Analysis test questions, in terms of mathematical creativity. In this research, Newman Error Analyze (NEA) was revealed according to [22] the type of student error in working on math problems caused by Reading Errors, Pretension Errors, Transform Errors, Process Skill Errors, and Encoding Errors. Furthermore, whether in this study there are types of errors other than the five types of errors above.

Based on the description above, this paper aims to analyze the location and causes of student errors in working on the Real Analyst exam subject material on open-ended Sequences and Series.

2. Method

This study used qualitative research methods. The research subjects were students who took the Real Analysis II course in the Mathematics Education Study Program at Pancasakti University Tegal in the Academic Year 2018/2019, as many as 64 students. Instruments in the form of tests and interviews. The data is in the form of the results of the real analysis course work on the Sequences and Series material in the Academic Year 2018/2019. The research was conducted in November 2018, located in the Mathematics Education Study Program at Pancasakti University Tegal. The variable used in this study is mathematical creativity.

3. Results and Discussion

Based on the results of this study, of the 64 students who took the Real Analysis course, most of the 39 material students still did not understand the correct theorem used to prove the problem. This is shown from the answer sheets of students answering, that there are still a lot of scribbles theorems to be used, meaning that the process of skill and transformation is still lacking. From this condition, it is necessary to instill in students before answering questions that must be in the initial analyst.

The purpose of this initial analysis is so that students know the behavior of the condition of the problem, so students can use the theorem to solve the problem correctly. Then 16 student misconceptions were also found in answering the question. This is shown from the results of student answer sheets found students do not understand the purpose of the problem, so the answer has nothing to do with this problem. Then it was also found that 8 students did not work on the questions in the student answer sheet, it was found that students simply worked on the problems and were known, and 1 person had no work. while the students' mathematical creativity was still lacking based on the results of the open-ended real analyst test questions which were attended by 64 students obtained:

Table 1. Achievements of Mathematical creativity

Number	Aspect	the number of students	student answers
1.	Fluency	0	There were no students who answered the three questions correctly
		5	Can answer two questions correctly
		22	Can answer one problem correctly
		17	Answering two questions but not quite right
		11	Answering one question but not quite right
		8	Write questions and know
		1	Write a question
2.	*Flexibility*	5	Give the right answer in two ways but it is incomplete and incorrect
		22	Give the right answer in one way but solve it correctly
		11	Give answers in one way with the right process but the results are wrong
		8	Gives one answer but is wrong
		8	Write questions and know
		1	Write a question

Number	Aspect	the number of students	student answers
3.	*Originality*	12	Answering correctly from doing it yourself
		16	Answering correctly from asking with friends
		20	Answering incorrectly from doing it yourself
		7	Answering incorrectly from the results of asking a friend
		8	Write questions and know
		1	Write a question

Based on the research results above, the questions used to determine the location and type of student error in the Real Analysis course are a matter of description. The description of the problem can be seen in the location and type of student error in working on the problem of Real Analysis that is Open Ended. The description questions given are Open-Ended questions. With the Open-Ended question, students are expected to be able to develop mathematical creativity.

The location, causes and types of errors found in students in carrying out tests on Open Analysis Real questions in this study there are eight types of errors namely five types of errors according to NEA from [22], namely: Reading Error, Comprehension Error, Transformation Error, Skill Error Process, and Encoding Error. Then in this study also found 3 types of errors that are different from the type [22] namely the first mistake of the careless student, this could be because the student was not careful when reading the problem or it could be that the student could not manage the time when working on the test questions, that is, students hastily worked on it, it could also be students lacking accuracy in working on the workflow. Then the second type of error is that students do not work on the problem at all, it could be that the problem is very difficult for the student, because the students are very heterogeneous. Furthermore, the third type of error is a misconception, errors of this type can occur because the student can only memorize theorems or problems but not those discussed but do not know the concept.

Based on the results of the Real Analysis course test material above, mathematical creativity can be said to below. Therefore, mathematics education students need to be instilled early on in mathematical creativity so that their mathematical creative thinking abilities increase. As said by ([5], [6],[4],[7],[8],[9], &[10]). Likewise, for students to work on real analysis subject matter, training is often given as an assignment, both structured and not so that students are accustomed to working on questions that are high-level thinking categories so that their mathematical creativity increases as ([13],[14],[16],[19],[20], &[21])

4. Conclusion and suggestions

The results obtained by eight types of student errors in working on the Open-Ended Real analysis test questions. these types of errors include five errors according to the mistakes of experts in Mathematics Education [22]. Then found 3 new types of errors that are different from [22] namely students are careless in working on these problems, students do not work on problems at all, and the existence of misconceptions.

Based on the research results above, the students' mathematical creativity is still low. Instilling the creative character of students from the beginning of entering college, students are allowed to practice both formally and informally to work on high-level questions for about five semesters. In the fifth semester when taking the course of real analysis, the ability to think creatively mathematics has been formed.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6