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Error Analysis in Solving Calculus Course Problems Assisted by Artificial Maps Based on SOLO Taxonomy Students of the Department of Mathematics Education, Faculty of Tarbiyah and Teacher Training at State Islamic University Alauddin Makassar

*Samriana[1]

[1]*Mathematics Education Master's Program, Universitas Negeri Makassar, Makassar, Indonesia*
**Corresponding author. Email: samrianahasma@gmail.com*

ABSTRACT

This research discusses the analysis of student errors in solving problems in the artificial map-assisted calculus course based on the SOLO taxonomy of the second semester of 2020 students majoring in mathematics education, Faculty of Tarbiyah and Teacher Training at UIN Alauddin Makassar. The type of research is qualitative research by giving questions in the form of diagnostic tests to research subjects, in this case, semester 2 students majoring in mathematics education class 2020, Faculty of Tarbiyah and Teacher Training at UIN Alauddin Makassar. The researcher selected five respondents based on the level of response to the SOLO taxonomy obtained by the students. The results of the study based on the questions given to 62 students obtained the percentage of student response rates as much as 25.80% of the number of students at the pre structural level; 43.54% are at the uni structural level; 24.19% are at the multi structural level, 6.45% are at the relational response level than 0% are at the extend abstract response level, so it can be concluded that the second-semester students majoring in mathematics education class 2020, Faculty of Tarbiyah and Teacher Training UIN Alauddin Makassar are at the level of uni structural response. Factors causing students to make mistakes in answering these questions, namely: the cause of misunderstanding the concept is a theorem or formula that is not in accordance with the prerequisite conditions for the application of the formula and is not even able to write the right formula; the cause of data entry errors is an error in entering data into variables and adding data that is not needed in answering a problem; the causes of language interpretation errors are errors in interpreting symbols into mathematical language; the cause of technical errors is an error in manipulating algebraic operations, and the reason of the mistake of concluding is to conclude statements that are not in accordance with logical reasoning.

Keywords: *Error Analysis, Calculus, Taxonomy on SOLO.*

1. INTRODUCTION

Education is an important part of human life that will be needed until the end of his life. Education makes humans try to develop themselves to face any changes due to advances in science and technology. The success of national education is a general goal to develop every human being who has the quality to answer every challenge of the times. Because from time to time it constantly changes in every development. As part of a culture, education focuses on the teaching and learning process to help students explore, discover, learn, know and live up to the good values for themselves, society, or the country. The Government of the Republic of Indonesia is determined to provide opportunities for all Indonesian citizens to enjoy quality education as the main step in improving citizens' standard of living. Education is responsible for developing and passing on the students' values; the values will also be transferred in their daily lives [1].

Today the quality of education in Indonesia has begun to experience a significant increase. This can be seen from the rise of international achievements in education, one of which is in the field of mathematics. Mathematics is a field of study studied by all levels of

education from elementary to high school, even in college. Various opinions arise about mathematics viewed from different knowledge and experience. Some say that mathematics is a language of symbols, mathematics is a numerical language, mathematics is a method of logical thinking, mathematics is a means of logical thinking, mathematics is the queen of science as well as its servant, mathematics is the science of quantities and quantities, mathematics is a science that manipulates symbols, Mathematics is a science that studies the relationship of patterns, shapes, and structures. Mathematics is an abstract and deductive science, and mathematics is a human activity [2].

Mathematics, as basic science, is an abstract object. The existence of this abstract nature can make it difficult for students to understand mathematics. This raises the assumption that mathematics is a complicated subject because most students do not understand mathematical concepts or misunderstand mathematics, causing students to experience difficulties in learning. Difficulties experienced by students will result in errors made in answering questions [3]. The causes of students making mistakes are generally divided into two factors, namely cognitive and non-cognitive factors. Cognitive factors include intellectual ability and how to understand mathematical material. At the same time, non-cognitive factors include family background, health, economic and social conditions [4]. However, examining non-cognitive factors requires a longer time and requires more complex indicators. Therefore, in this study, cognitive factors are used, namely, factors originating within students, namely students' intellectual abilities in understanding calculus II courses.

In the mathematics education department, there are 52 courses with a total number of 146 credits. One of the courses in the mathematics education department is the calculus II course. The calculus II course is one of the required courses when taking lectures in the mathematics education department for 2nd-semester students. The calculus II course contains indefinite integrals, sums and sigmas, substitution integrals, and partial integrals. The calculus II course is a follow-up course from the previous course, namely the calculus I course. This calculus II course is used as the basis for mastering subsequent courses such as ordinary differential equations, geometry, and complex numbers. Calculus II is prerequisite material for mastering ordinary differential equations,

Students are majoring in mathematics education come from high schools (SMA), and some are from vocational high schools (SMK). In the first year, it will be difficult for students to adjust their abilities in dealing with the materials in the courses they study, especially in the calculus II course. The calculus material has been mastered well to solve these problems because the calculus II material has a lot to do with other materials. However, the existing facts show the opposite condition. Students who come from high school should master calculus II material well to solve any problems related to calculus II courses.

Based on the results of the initial interview on September 10, 2020, which was conducted with students majoring in mathematics education for semester 2 students, an overview of the errors made by students in solving problems occurred due to a lack of understanding of the basic concepts that students must master, such as integral material and derived material. This is in accordance with interviews conducted with students (S-01) who said that there was a lack of understanding of the calculus II course, working on problems with formulas that were not appropriate, for example, indefinite integral formulas were solved with definite integral formulas, and many students knew the formulas by memorizing instead of by understanding the concept of the formula that has been studied in working on the given problem.

This is in accordance with the results of interviews conducted with lecturers in calculus II courses on September 12, 2020, which stated that the difficulties experienced by students in studying calculus II courses were due to the weakness of the prerequisite material possessed by students, lack of mastery of the basic concepts of calculus II so that This causes frequent errors in solving calculus II problems. The level of student response in solving problems needs to be known by the lecturer as an educator. After the lecturer knows the level of student response, the lecturer will also learn how far the level of student absorption is in studying calculus II courses. Lecturers can detect the position of the response structure that students have cognitively.

The application of the SOLO taxonomy is very appropriate to determine and analyze the quality of student responses in solving problems. The SOLO taxonomy is an easy and simple tool to assess the level of student response to a math question and categorize student errors in solving student problems or questions. Thus, the SOLO taxonomy can determine the difficulty or complexity of a problem based on the structure of the observed learning outcomes. The SOLO taxonomy is divided into five distinct and hierarchical levels: pre-structural, uni structural, multi-structural, relational, and extended abstract [5].

In addition, based on research conducted by Marlyana, it shows that the study obtained five taxonomic levels of SOLO (Structure of Observed Learning Outcomes) with large presentations, namely the pre structural level 5.17%, uni structural level 7.75%, multistructural level 18.10%, relational level 51.72%, and the extended abstract level is 17.24%. The results showed that students' errors at the relational level were more dominant than at other levels with the principle error type. Student errors at the relational level are caused by the hasty attitude of students in working on questions, and students do not review or re-examine the answers they have worked on [6].

2. RESEARCH METHOD

This type of research is qualitative research with descriptive qualitative method. Descriptive qualitative is a research method that aims to describe incomplete and in-depth the social reality and various phenomena in the community that is the subject of research. These phenomena' characteristics, characters, traits, models are described [7]. This research collected information about student errors in solving problems in the calculus II course obtained from research subjects based on the SOLO taxonomy level. The data source is selected by purposive sampling.) purposive sampling is a sampling technique with certain considerations applied by researchers [8]. The data collection technique in this study is a diagnostic test. The diagnostic term, which originally said diagnosis, is an attempt to find a disease or weakness experienced by a person through the testing process to obtain an accurate decision on the symptoms of something [9]. In-depth interviews using research instruments, namely the researcher himself and several supporting instruments such as diagnostic test instruments, interview guides. To ensure the validity of the data, the data credibility test technique is carried out, namely by triangulation, namely using technical triangulation. The data analysis techniques used are data reduction (data reduction), data display (data presentation), and conclusion drawing/verification (concluding).

3. RESULTS AND DISCUSSION

Based on the results of the analysis of student errors when working on the questions, the researchers concluded the quality of the responses of each student based on the SOLO taxonomy with the results presented as follows:

Based on the results of the percentage of students who are in the level of student response quality based on the SOLO Taxonomy in table 1, it can be described that each student's response quality based on the SOLO taxonomy is 25.80% of the number of students at the pre structural response level; 43.54% are at the uni structural response level; 24.19% are at the multistructural response level, 6.45% are at the relational response level, and 0% are at the extend abstract response level, it is concluded that the second-semester students majoring in mathematics education class 2018 Faculty of Tarbiyah and Teacher Training UIN Alauddin Makassar are at the level of uni structural response.

Table 1. Quality of Student Answers Based on SOLO Taxonomy

Taxonomy SOLO	Research subject	Amount	Percentage
Prestructural	S-01, S-02, S-05, S-22, S-23, S-24, S-26, S-27, S-29, S-30, S-33, S-38, S-42, S-57, S-59	16	25.80%
Unistructural	S-03, S-04, S-08, S-09, S-10, S-11, S-12, S-13, S-14, S-16, S-17, S-20, S-21, S-25, S-28, S-32, S-34, S-35, S, S-36, S-37, S-39, S-43, S-44, S-45, S-45, S-52, S-53, S-61.	27	43.54%
Multistructural	S-06, S-07, S-15, S-18, S-19, S-31, S-41, S-48, S-51, S-54, S-55, S-58, S-60 S-562.	14	24.19%
Relational	S-40, S-47, S-49, S-50.	4	6.45%
Extended Abstract	-	0	0%

3.1. Description of SOLO Taxonomy

Based on the description of the results of tests and interviews conducted on students, it can be seen the mistakes made by students in solving calculus II questions. The results of the data analysis indicate the types of errors and the level of response quality according to the SOLO taxonomy. Through the results of data analysis, it is also known the causes of errors made by students. The following is a discussion of the results of the analysis of the data obtained.

3.2. Student Response at Prestructural Level

The pre-structural level is where students have very little information that is not even interconnected, so it does not form a unified concept and does not have any meaning. So that students at the pre-structural level have not been able to work on the questions given correctly, students do not have skills that can be used in solving problems and do not even understand what to do. One of the things that can be seen at this level is that students cannot write down what they know and what they are asked about, do not know what the content of the questions is, cannot analyze what the questions mean, cannot write mathematical symbols correctly, such as being unable to distinguish symbols. Integral, so on.

Judging from the percentage results obtained in table 1 of the SOLO taxonomy description, 25.80% of students were at the pre-structural level by making all kinds of errors, namely errors in understanding concepts, errors in entering data, language interpretation errors, technical errors, and errors in concluding. This research is strengthened by the results of Asikin's [10] research, which concludes that at the pre-structural level, students refuse to give answers, answer quickly based on observation and without a logical basis.

3.3. Student Response at Unistructural Level

There is a clear and simple relationship between one concept at this uni structural level, but the concept's core is not widely understood. Some verbs that can identify activities at this stage are; recognizing, remembering, and performing simple procedures. It can be seen that students who fall into this category make mistakes in doing the next step after completing one stage, can already write down what is known and asked, write down the formula that must be used but has not been able to apply it to what the question wants. Based on table 1 obtained a percentage of 48.38% for the uni structural level.

3.3.1. Student Response at Multistructural Level

At the multi-structural level, students can respond to problems with several separate strategies, many relationships can be made, but these relationships are not yet precise. Students who fall into this category can read the questions well, know the contents of the questions, what the questions want, and know the steps or procedures that must be taken even though the steps are not correct. Seeing the types of questions which are description questions, high analytical skills are needed from students to solve the questions given. Based on table 1 obtained a percentage of 20.96% for the multi-structural level. At the multi-structural level, this is a category of student response quality that describes moderate ability.

3.3.2. Student Response at the Relational Level

Students at the relational level can break a whole into parts and determine how these parts are related to several models and can explain the equivalence of these models. However, it can be seen in table 1: the percentage of students' relational response quality level is 4.83% which is in this relational level. Students who meet the quality level of rational responses are students who can connect facts with theory as well as actions and goals.

This research is strengthened by the results of Pratiwi's study [11], which concludes that at the relational level, 27.1% of students are obtained, which indicates that students can connect some data or information and then apply concepts and make relevant conclusions. This means that students who can complete tasks or work to the relational level can understand, plan and complete their work appropriately and provide relevant findings.

3.3.3. Student Responses at the Extended Abstract level

At this stage, students can make connections not only limited to the concepts given but also concepts outside of that. In other words, students must have mastered the material and understand the questions given very well to realize these concepts. Existing concept. However, it can be seen in table 1: the percentage of the quality level of the Exented Abstract response of students is 0%, which means that none of the students meet the quality level of the Exented Abstract response. At this level, students should have mastered all the concepts that exist. This research is strengthened by [12] with the research title "Analysis of Student Errors in Solving Problems on Geometry Materials Based on Solo Taxonomy Class VII MTS. Muhammadiyah Tanetea, Jeneponto Regency, and the percentage of students' Exented Abstract response quality level is 0%, which means that none of the students meet the Exented Abstract response quality level. At the level of students have mastered all the concepts that exist.

3.4. Factors Causing Student Errors Based on SOLO Taxonomy

Based on the results of diagnostic tests and interview results obtained from 5 research subjects, it can be seen that all subjects made errors in the questions given. The following is a discussion of errors made by research subjects and the factors that cause students to make mistakes.

3.4.1. Errors made by research subjects at the pre structural level

16 students entered the pre-structural level in this study. Among them; S-01, S-02, S-05, S-22, S-23, S-24, S-26, S-27, S-29, S-30, S-33, S-38, S- 42, S-57, and S-59. This is known when the process of analyzing student answers is carried out. The cause of the subject being included in this pre structural category is the subject which almost makes all kinds of errors in solving the problem, including:

1) Misunderstanding the concept is wrong in determining the theorem or formula in answering the question, not writing the formula in answering the question; the steps for solving the problem are not appropriate. This is due to not knowing and understanding the intent of the questions and not knowing what information is contained in the questions, and not mastering the prerequisite material from the calculus II course.
2) Errors in entering data, namely entering data that should not be used in answering questions, entering incorrect data into variables, causing a rush in working on questions.
3) Language interpretation errors are caused by not being able to express everyday language into mathematical languages, such as forgetting to write the symbol of integral in providing problem-solving and has not been able to describe the graph correctly according to the question request
4) technical errors are caused by a lack of accuracy in doing calculations and writing answers and a lack of skill in manipulating algebraic operations, especially on roots and exponents.
5) Conclusion drawing errors are caused by not re-examining the final answers given and not managing the time to work on the questions correctly.

Apart from the 5 types of errors made by research subjects at this pre-structural level, there were even subjects who did not provide answers because they did not understand everything about the questions.

3.4.2. Mistakes made by subjects at the uni structural level

27 students entered the uni structural level in this study. Among them; S-03, S-04, S-08, S-09, S-10, S-11, S-12, S-13, S-14, S-16, S-17, S-20, S- 21, S-25, S-28, S-32, S-34, S-35, S, S-36, S-37, S-39, S-43, S-44, S-45, S-45, S-52, S-53, and S-61. This is known when the process of analyzing student answers is carried out. The cause of the subject being included in this uni structural category is that the subject still makes many types of errors in understanding concepts, language interpretation errors, data entry errors, and concluding. This is because the subject can only respond to questions and has not understood the contents of the questions correctly.

3.4.3. Mistakes made by subjects at the multi structural level

Fifteen students entered the multi-structural level in this study. Among them; S-06, S-07, S-15, S-18, S-19, S-31, S-41, S-48, S-51, S-54, S-55, S-58, S- 60 S-562. This is known when the student answer analysis process is carried out. The cause of the subject being included in this multi-structural category is that students still make mistakes in connecting the results of their analysis correctly, still entering incorrect data, or adding unnecessary data to answer questions. Also, there are still subjects entering the wrong formula in solving the problem

3.4.4. Mistakes made by subjects at the relational level

Four students fall into the relational category. These include the S-40, S-47, S-49, and S-50. as has been explained that students at the relational level can solve a problem into parts and determine how the parts are related to several models and explain the equivalence of the model. In other words, students who fall into this category make only a few mistakes in answering questions.

3.4.5. Errors made by the subject at the level of extended abstract

At the extended abstract level, no students belong to it. Students in this category should have mastered the material and understand the questions given very well to realize the existing concepts. Only students who do not make mistakes are included in the extended abstract category. Meanwhile, there is not a single student included in the extended abstract category of the sixty-two students studied.

4. CONCLUSION

Errors made by students in solving calculus II course questions with the aid of artificial maps based on SOLO taxonomy are as follows: Misunderstanding concepts, namely incorrectly determining theorems or formulas in answering questions, not writing formulas in answering questions, incorrect problem-solving steps. This is due to not knowing and understanding the intent of the questions and not knowing what information is contained in the questions, and not mastering the prerequisite material from the calculus II course. Errors in entering data, namely entering data that should not be used in answering questions, entering incorrect data into variables, causing a rush in working on questions. Language interpretation errors are caused by not

expressing everyday language into mathematical languages, such as forgetting to write the symbol of the integral in providing problem-solving and not describing the graph correctly according to the question request. Technical errors are caused by a lack of accuracy in doing calculations and writing answers and a lack of skill in manipulating algebraic operations, especially on roots and exponents. Errors in concluding are caused by not re-checking the final answers given and not managing the time to work on the questions correctly.

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