



Journal of Education and Learning Mathematics Research (JELMaR)

Online ISSN : 2715-9787

Print ISSN : 2715-8535

Journal Homepage : <http://jelmar.wisnuwardhana.ac.id/index.php/jelmar/index>

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To cite this article Sulistyaningtyas, A., & Wantika, R. (2023). Analysis of Student Learning Difficulties in Solving Calculus II Course Case Studies. *Journal of Education and Learning Mathematics Research (JELMaR)*, 4(2), 171-178.

<https://doi.org/10.37303/jelmar.v4i2.119>

To link this article : <https://doi.org/10.37303/jelmar.v4i2.119>

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Publisher

Department of Mathematics Education,
Faculty of Teacher Training and Education,
Universitas Wisnuwardhana Malang

Analysis of Student Learning Difficulties in Solving Calculus II Course Case Studies

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Abstract: *Calculus II is a compulsory course in the Mathematics Education Study Programme of PGRI Adi Buana University Surabaya which is programmed by third semester students. This course learns about the basic concepts of integrals and their applications, so students are required to be able to understand and analyse problems appropriately. This study aims to determine the difficulties experienced by students in solving Calculus II problems as well as to find out the causes. The research subjects were five students of Mathematics Education of Universitas PGRI Adi Buana Surabaya in the academic year 2022/2023. This research uses a qualitative approach using test and interview methods. The results obtained from this study are in the form of types of student difficulties in solving problems, namely difficulty in determining the final result, difficulty in understanding the concept of function decomposition, difficulty in applying concepts to problems, difficulty in calculating, difficulty in starting the first step of the calculation. Furthermore, for the causes of these difficulties, including, lack of accuracy in understanding the problems given, lack of mastery of concepts, errors in the calculation process, and lack of understanding of the concept of initial identification of integral forms.*
Keyword: *Learning difficulties, qualitative approach, integral*

INTRODUCTION

Based on the Decree of the Minister of Education and Culture of the Republic of Indonesia Number 3/M/2021 of the Main Performance Indicators of Higher Education and Higher Education Service Institutions, it is explained that classroom learning is expected to use the *case method*, where students act as "protagonists" who try to solve a case or project-based group learning (*team-based project*) where the class is divided into groups to work on joint tasks for a specified period of time as part of the evaluation weight. For this reason, students are required to carry out active self-learning activities to support their understanding of the material provided.

In this regard, there are many things that are learned in mathematics by students, so it is often found that students experience difficulties in learning mathematics. (Sugiarti 2017). One of the courses that must be studied by students of the Mathematics Education study programme is Calculus II. Calculus II is a course that learns about the basic concepts of integrals and their applications. In the Mathematics Education study programme at PGRI Adi Buana University Surabaya, Calculus II is a prerequisite course for taking further courses, so it is hoped that students will not experience difficulties when studying the course. (Sumargiyani and Nafi 2020).

Students' difficulties in working on mathematics problems need to be analysed further in order to find out the factors that cause them so that they can overcome the problems of students who experience various mistakes in working on these problems. Analysis of student learning difficulties has been carried out by (Monariska 2019). In his research, it was found that student learning difficulties lie in errors in understanding the problem, errors in process skills, and errors due to lack of care in working on problems and managing the time provided so that the problem cannot be resolved properly. Research on the analysis of learning difficulties of Mathematics Education study programme students was also conducted by (Qomariyah and Rosyidah 2022). The study was conducted to analyse the level of difficulty in the Real Analysis II course. The instrument used in data

collection is a questionnaire which is analysed quantitatively using percentage techniques to determine the high and low difficulty of student learning in the course. The results showed that the factors that influence learning difficulties include self, family environment, school environment, and office or community environment. Research on the analysis of learning difficulties for Mathematics Education study programme students has also been conducted by [5]-[9].

In connection with the above problems, the researcher intends to conduct research related to the analysis of learning difficulties of Mathematics Education study programme students at Universitas PGRI Adi Buana Surabaya in solving problems in Calculus II courses. From the results of this study, data were obtained regarding what difficulties students experienced when studying Calculus II courses. In addition, the causes of these difficulties are also known.

METHOD

This research uses a qualitative descriptive research approach. It aims to describe the errors made by students in solving problems and find out the factors that cause student difficulties in solving problems in Calculus II courses. This research was conducted at the Mathematics Education Study Programme, Faculty of Science and Technology, Universitas PGRI Adi Buana Surabaya. The implementation time was carried out in the odd semester of the 2023/2024 academic year. The subjects of this study were five students of the Mathematics Education Study Program, Faculty of Science and Technology, Universitas PGRI Adi Buana Surabaya in the academic year 2022/2023 who were studying Calculus II.

Data collection techniques in this study used test and interview methods. Tests were conducted to find out the location and types of student difficulties in solving Calculus II problems. Meanwhile, interviews were conducted to strengthen and complement the data from the written test results and to find out the answers directly about the difficulties and causes in solving the test questions.

Hold research data analysis used is descriptive narrative using the Miles and Haburman Model, which is presented in Figure 1. (Pasaribu 2021).



Figure 1. Data Analysis Stage

Based on Figure 1, the data analysis stage is explained as follows: 1) the data reduction stage is carried out by correcting the results of student answers and identifying the difficulties found, as well as analysing the results of student interviews selected based on the difficulties that have been found; 2) presenting data is done by presenting the results of student interviews that have been selected for the analysis process, and 3) drawing conclusions is done by comparing the results of the answers to the questions and interviews conducted, so that conclusions will be obtained as answers to the formulation of research problems.

RESULT AND DISCUSSION

Based on the results of the Midterm Examination (ME) for the odd semester of 2023/2024 academic year 2023/2024, students of the Mathematics Education Study Program at Universitas PGRI Adi Buana Surabaya, researchers obtained data showing that students had difficulty learning Calculus II. After the results of the written exam were analysed, an

interview test was conducted with subjects who had been randomly selected to find out the difficulties and factors that caused them during the process of working on Calculus II problems.

The implementation of the research began after the Midterm Examination (UTS) of the odd semester 2023/2024 in room J.101 Campus II PGRI Adi Buana University Surabaya. Calculus II written test questions as many as 5 (five) questions. UTS was attended by 18 students, then the research subjects were selected 5 (five) students. The research subjects were chosen based on several considerations, including, (1) students with test results who made many mistakes, (2) students with errors on each number varied, and (3) the availability of students as research subjects. The following are the questions and 5 (five) research subjects selected:

Table 1. Calculus II exam questions

No.	About
1	Given $\theta = \sin^{-1}\left(\frac{1}{2}\sqrt{2}\right)$. Find the exact value of $\cos \theta$.
2	Obtain the decomposition form of rational functions and determine the coefficients of $\frac{1-3\theta^4}{(\theta-2)(\theta^2+1)^2}$.
3	Get the integral value of $\int \frac{e^x}{\sqrt{1-e^{2x}}} dx$.
4	Get the integral value of $\int x^2 \sin 3x dx$
5	Get the integral value of $\int \frac{\sqrt{x}}{1+\sqrt[3]{x}} dx$.

Table 2. List of Selected Research Subjects

No.	Code Name
1	APW
2	BOARD OF TRUSTEES
3	ZDA
4	MQ
5	NS

A. Document Analysis of Written Test Results

In this section, the researcher analyses the data that has been obtained, namely the results of the Midterm Examination (UTS) that has been done by the research subject. The results of data analysis or test results are as follows:

Handwritten work on lined paper showing two parts of a problem. Part 1: $\theta = \sin^{-1}\left(\frac{1}{2}\sqrt{2}\right)$ followed by $\theta = \frac{\pi}{4} = 45^\circ$. Part 2: $\cos \theta = \cos 45^\circ = \frac{1}{2}\sqrt{2}$.

Figure 2. Errors in determining θ

In **Figure 2**, the discussion of question 1 is explained. In the answer to question number 1, APW students had difficulty in determining the value of θ . In question 1, the value of $\theta = \sin^{-1}\left(\frac{1}{2}\sqrt{2}\right)$, where the value should be θ is in quadrants I and II, namely $\theta = \frac{\pi}{4}$ or $\theta = \frac{3\pi}{4}$. Meanwhile, the results of APW are still inaccurate because it only gives the answer to the value of θ in quadrant I, namely $\frac{\pi}{4}$.

In **Figure 3**, the discussion of question 2 is explained. In the answer to question number 2, MWA students had difficulty in identifying the decomposition of rational functions. $\frac{1-3\theta^4}{(\theta-2)(\theta^2+1)^2}$. The rational function is a type of rational function with a denominator consisting of linear factors and repeated quadratic factors, so the description of the solution

Handwritten work on lined paper showing the decomposition of a rational function. It starts with: $2.) a. \frac{1-3\theta^4}{(\theta-2)(\theta^2+1)^2} = (a+b)^2 = (a^2 + 2 \cdot ab + b^2)$. The next line is $= \frac{1-3\theta^4}{(\theta-2)(\theta^2+2\theta^2+1)}$. The third line is $= \frac{1-3\theta^4}{\theta^5 + 2\theta^3 - \theta - 2\theta^4 - 4\theta^2 - 2}$. The final line is $= \frac{1-3\theta^4}{\theta^5 - 2\theta^4 + 2\theta^3 - 4\theta^2 - \theta - 2}$.

Figure 3. Errors in understanding the concept of decomposition of a given rational function

of the function should be as follows:

$$\frac{1-3\theta^4}{(\theta-2)(\theta^2+1)^2} = \frac{A}{\theta-2} + \frac{B\theta+C}{\theta^2+1} + \frac{D\theta+E}{(\theta^2+1)}$$

In addition, MWA also has not determined the coefficients of A, B, D, E. so the work on the problem by MWA is still incomplete.

In **Figure 4**, the discussion of the problem by student ZDA is explained. Based on the results

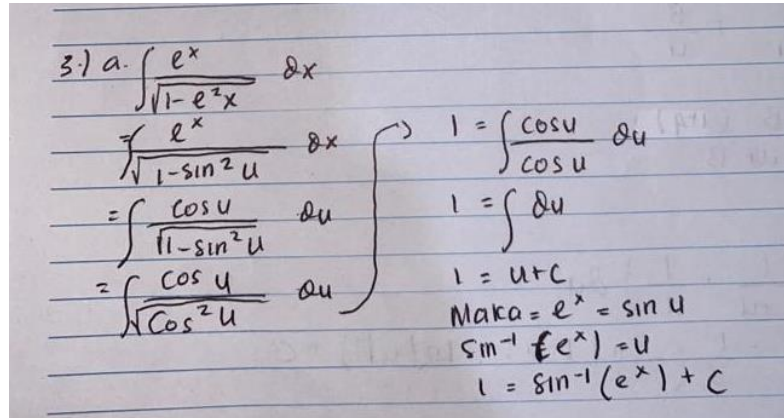


Figure 4. Errors in applying concepts to problems

of the final exam that ZDA has done, ZDA has difficulty in identifying the integration technique used to complete the integral process of the function. In this problem, the integration technique used is the substitution method and the integration of trigonometric functions of the form *sin*. The initial step that should be done is to make the following equation:

$$u = e^x$$

So that the form is obtained $\int \frac{1}{\sqrt{1-u^2}} du$ and can then be solved by using the integration form of the sine integration function and converted into the form of variables *x*.

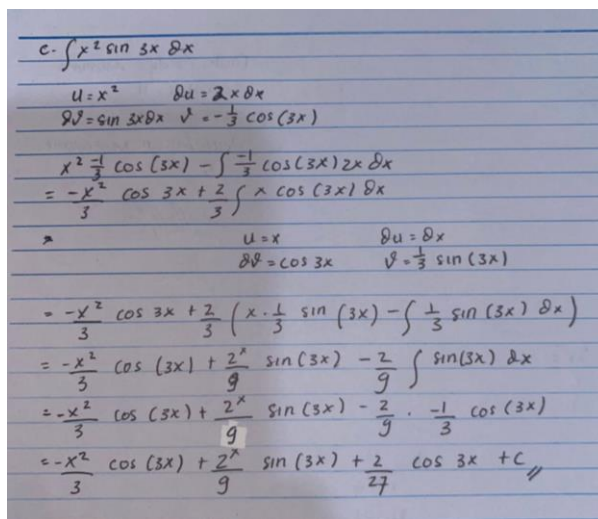


Figure 5. Calculation errors in the integration process

In **Figure 5**, student MQ made a mistake in writing the function equation during the integration process, namely in the product of $\frac{2}{3}\left(x \cdot \frac{1}{3}\sin(3x)\right)$. MQ wrote that the result of the multiplication is $\frac{2^3}{9}\sin(3x)$. The answer is of course not correct, because MQ is not careful.

In **Figure 6**, student NS has solved the integral function problem. However, NS had difficulty in determining the integration technique used and was less thorough in

3) d. $\int \frac{\sqrt{x}}{1+\sqrt{x}} dx$

$u = \sqrt{x} \quad u^3 = x$

$dx = \frac{du}{3u^2}$

$\int \frac{\sqrt{x}}{1+\sqrt{x}} dx = \int \frac{\sqrt{u^3}}{1+u} \cdot \frac{du}{3u^2}$

$= \frac{1}{3} \int \frac{u^2}{1+u} du$

Misal $\frac{u^2}{1+u} = \frac{A}{1+u} + \frac{B}{u}$

$u^2 = A \cdot u + B \cdot (1+u)$

$u^2 = (A+B)u + B$

$A+B = 0$

$\frac{1}{3} \int \frac{u^2}{1+u} du = \frac{1}{3} \int \left(-\frac{1}{1+u} + \frac{1}{u} \right) du$

$= \frac{1}{3} \int \left(-\frac{1}{1+u} + \frac{1}{u} \right) du = \frac{1}{3} \left(-\ln|1+u| + \ln|u| \right) + C$

$\therefore \int \frac{\sqrt{x}}{1+\sqrt{x}} dx = \frac{1}{3} \left(-\ln|1+\sqrt{x}| + \ln|\sqrt{x}| \right) + C$

Image 6. Error in determining the first step in the calculation

calculating the derivative of the function, namely the integration technique used for the rational function, where NS used the integration technique with the substitution and derivation method for the rational function. $\frac{\sqrt{x}}{1+\sqrt{x}}$, where NS used the integration technique with the substitution method and the function derivative for $u^3 = x$, where the error lies in $dx = \frac{du}{3u^2}$.

B. Document Analysis of Interview Results

Based on the results of interviews conducted by researchers after the exam was held, in principle, students have understood the explanations given by lecturers during teaching and learning activities, but when students are faced with certain problems or case studies, they are confused in identifying these problems or case studies, so that students make mistakes in the process of working on Calculus II exam questions. The following are some of the factors that cause difficulties caused by students in solving problems or problems in Calculus II courses.

1. In question 1, students were not careful in determining the value of θ value, so they are only fixated on the value of θ in quadrant I, while in the problem there is no value limit given. θ given, so the value of θ on the interval $[0, 2\pi]$. Overall, students have understood the theory and the process of obtaining solutions.
2. In problem 2, students have difficulty in understanding the concept of decomposition of rational functions given, students are confused in defining the form or type of rational function, so they have difficulty in getting the value of coefficients A, B, C, D, E.
3. In question 3, students had difficulty in determining the variables to be substituted, so the next calculation also made mistakes. This is because students do not write clearly the variable as the determinant of the equation to be substituted.

4. In question 4, students made mistakes in writing equations due to lack of focus and lack of thoroughness, resulting in different definitions of the final result even though the stages of work were correct.
5. In question 5, students had difficulty in defining the given function, resulting in confusion in determining the next integration technique.

CONCLUSION

Based on the results of the analysis and discussion that has been carried out by researchers, among others, about the difficulties experienced by students in solving Calculus II problems, namely (1) difficulties in determining the value of the final result, (2) difficulties in understanding the concept of function decomposition, (3) difficulties in applying concepts to problems, (4) difficulties in calculations, (5) difficulties in starting the initial step of calculation, and the causes of the difficulties experienced, (1) in problem 1, not carefully understanding the case study and problem boundaries given in the problem, (2) in problem 2, difficulties are caused because students do not master the concept, so they are confused when applied in the problem, (3) in problem 3, the cause of difficulties is due to errors in the initial calculation, (4) in problem 4, not being careful in the calculation process, (5) in problem 5, not understanding the concept of identifying the form of integration.

ACKNOWLEDGMENTS

My acknowledgments give to Universitas PHGRI Adi Buana Surabaya for providing material support through Adi Buana's Internal Grants. Hopefully, the publication of this article can bring Adi Buana even more grow up.

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