An Error Analysis's Students to Finding Solution From a Differential Equation

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***Abstract*— In solving the general solution of a differential equation UNRIKA students common mistakes made by students. This research is a quantitative descriptive study conducted on 44 semester V students in the 2018/2019 school year who took courses in differential equations. The instrument used in the form of essay test was 2 questions that were valid and reliable (r = 0.758). From the results of the analysis, mistakes made in the form of procedural errors, process errors and student understanding errors. The more frequent error is a process error, especially in algebraic processes in determining the general solution of a problem of differential equations. To that end, as educators, it should often be reminded to be careful in doing calculations, often repeat more varied material and provide contextual modules so that the concept of the material can be understood by students properly and correctly.**

Keywords— Error Analysis, Student's Error, Differential Equation

I. INTRODUCTION

Mathematics is a science derived from a thought and procedure for managing logic quantitatively and qualitatively that has an abstract objective object, relies on agreement and has a deductive mind set. In the process, it must understand the concepts given and repeat the material consistently or continuously[1]. Furthermore, one of the vocational mathematics courses that study first order differential equations and second order differential equations is in the differential equation courses. Where in its settlement uses the properties and theory of algebraic functions in its proof.

In the work of differential equations must be able to model a problem in the form of an equation. Models are mathematical representations of mechanisms that govern natural phenomena that are not fully recognized, controlled, or understood[2]. Algebraic equations describe relations among varying quantities. Differential equations go one step further. They describe, in addition to relations among changing quantities, the rates at which they change [3]. A differential equation is an equation involving derivatives of an unknown function that depends upon one or more independent variables. If the unknown function depends on only one independent variable, then the equation is called an ordinary differential equation [4].

In completing differential equations, previous students must be understands the subject that has been taught in calculus I, II and Advanced which are prerequisite material in differential equation courses. In general, in determining the solution of differential equations, students must master the concept of algebraic functions correctly. Nevertheless, many students make mistakes in solving differential equations. Where the error is a deviation from anything that has been predetermined. Munandar argues, mistakes are defined as deviations from the right thing and are systematic, consistent or incidental in certain parts[5]. Mathematical errors when viewed from the mathematical object found by Begle among others are factual errors, concept errors, operation errors, and principle errors. The type of error according to Clement is 1) *Coreless Error,* mistakes because of lack of accuracy or carelessness, this is like students lack understanding of the questions given, the meaning of words, not mastering the concepts and lack of mastery of calculation techniques. 2) Weakness in process skills, mistakes made in the process, where students have done the steps right but will be wrong in doing calculations 3) Reading comprehension, which is an error in understanding the problem, where students do not understand the purpose and objectives of the questions given, so that it does not provide a solution of the problem presented 4) Transform Error, namely transformation error, so students incorrectly transform verbal language into mathematical language and 5) encoding error, i.e. error using notation[6] .

Based on the results of observations of researchers in a few years teaching courses in differential equations, many students make mistakes in determining the general solution of a given differential equation. For this reason, this article aims to formulate the types of errors that are often made by students in determining the general solution of a differential equation.

II. METHOD

This research is a quantitative descriptive study. With the aim of knowing and describing errors that are often done by students in determining the general solution of a differential equation and knowing what factors cause the error to occur. The subject of the study was the 5th semester students of the 2018/2019 A.Y at the Mathematics Education Study Program in UNRIKA, who took courses on differential equations totaling 44 students.

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Data collection techniques in the form of documentation and interviews. The documentation referred to in this article is in the form of the results of the answers given by students in the Final Examination Semester (UAS) consisting of 2 question descriptions that have been valid and reliable amounting to 0.758. The questions to be analyzed are presented in the following table 1:

Table 1. Type of differential equation test

Subject	Number	Question
The particular solution	1	Using the parameter variation method, determine the value of the particular solution (Y_p) from equation $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = \frac{e^2}{x}$
Non homogeny differential equation	2	Determine the general solution of the following non homogeny differential equation $y'' - 3y' + 2y = e^{2x}$

The data analysis in this article follows the guidelines for categorizing the answers given by students in table 2

Table 2. NEA stages based on mistakes[re-6]

NEA Stages	Types of student mistakes
Reading (R)	The questions cannot be understood by students
Comprehension (C)	Understand all terms in the problem but don't know what the problem is asking for
Transformation (T)	Understand how to find solutions, but do not understand how to solve them
Process Skill (P)	Understand to solve the problem but can't solve the problem properly and correctly
Encoding (E)	Cannot write conclusions and final answers correctly

The next step is to calculate the results of the percentage score acquisition using the formula [7]

$$P = \frac{sum\ items}{\max score} x\ 100\%$$

Note: P = Score Percentage

III. ANALYSIS AND RESULTS

THE RESULTS OF EACH ITEM ARE PRESENTED IN TABLE 3 BELOW

Table 3: Students Value Acquisition

	Num 1	Num 2
Min Score	0	0
Max Score	25	25
Sum	695	475
% Achievement	63.18%	43.18%
Average	15.79	10.75
Variance	75.51	24.35
Total Avereage	26.59	
% Total Achievement	53.18%	

Then the process of analysis is carried out from the answers given by students, based on the guidelines given in table 2. The results obtained are as follows:

A. Description of students mistakes in the subject parameter variation

Table 4. Error Description about number 1

NEA's Step	Examples of student's Error	Frequency (students)	%
R	Students do not provide entries that mean they do not understand the concept	5	16.12%
C	Students are wrong in choosing the step of completion, which is wrong in determining the root characteristics.	4	12.90%
T	Error in transforming the formula accordingly (do not use the parameter variation method)	4	12.90%
P	Students are wrong in doing algebraic processes in solving problems	16	51.61%
E	Students are wrong in concluding the solution requested	2	6.45%
Sum		31	
Students who don't make mistakes		13	29.54%
TOTAL		44	

From table 4, there were 31 students who made mistakes and 13 students who answered correctly, so that only 29.54% of students could find the general solution of the requested differential equation.

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B. Description of students mistakes in the subject Nonhomogenic differential equation

Tabel 5. Error Description about number 2

NEA's Step	Examples of student's Error	Frequency (students)	%
R	Students do not provide entries that mean they do not understand the concept	6	17.14%
C	Students are wrong in choosing the step of completion, which is wrong in determining the root characteristics.	10	28.57%
T	Error in transforming the formula accordingly (do not use the parameter variation method)	1	2.85%
P	Students are wrong in doing algebraic processes in solving problems	15	42.85%
E	Students are wrong in concluding the solution requested	3	8.57%
Sum		35	
Students who don't make mistakes		9	20.54%
TOTAL		44	

From table 4, there were 35 students who made mistakes and 9 students who answered correctly, so that only 20.54% of students could find the general solution of the requested differential equation.

IV. DISCUSSION

By looking at table 4 and table 5 it is found that the biggest error occurs at the stage of the process, where 51.61% and 42.85% of students are wrong in doing the algebraic process to determine the general solution of a differential equation. For more details, will be detailed based on each item.

A. An Error Analysis in the subject parameter variation

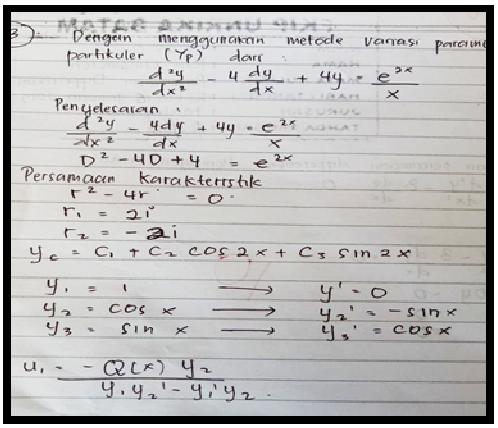

Figure 1. Error Comprehension question from No.1

In Figure 1 above, it shows that students are wrong in choosing a step in finding a general solution in a differential equation. The error made occurs in determining the root characteristics, namely:

$$\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = \frac{e^{2x}}{x}$$

$$D^2 - 4D + 4 = e^{2x}$$

$$r^2 - 4r = 0$$

$$r_1 = 2i \; atau \; r_2 = -2i$$

$$Y_c = C_1 + C_2 \cos 2x + C_3 \sin 2x$$

The right process should be:

$$\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = \frac{e^{2x}}{x}$$

$$D^2 - 4D + 4 = e^{2x}$$

$$r^2 - 4r + 4 = 0$$

$$r_1 = 2 \; atau \; r_2 = 2$$

$$Y_c = C_1 e^{2x} + C_2 x e^{2x}$$

Furthermore, errors that often occur in the Encoding step as shown in Figure 2

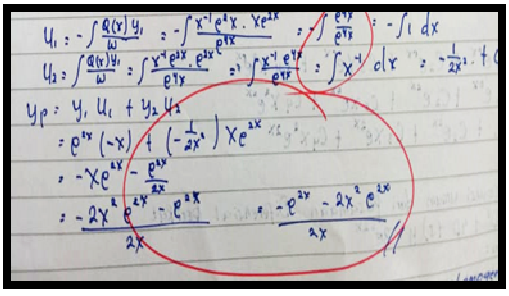

Figure 2. Error Encoding Step from number 1

The figure above shows that students incorrectly concluded the correct answer to provide a general

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solution to a given differential equation. The error made was

$$Y_p = -xe^{2x} + \frac{1}{-2x}xe^{2x}$$

Which

$$Y_p = -xe^{2x} + C_1e^{2x} + \ln(x)\,xe^{2x} + C_2xe^{2x}$$

B. Error analysis in the Nonhomogen Differential Equation Submersion

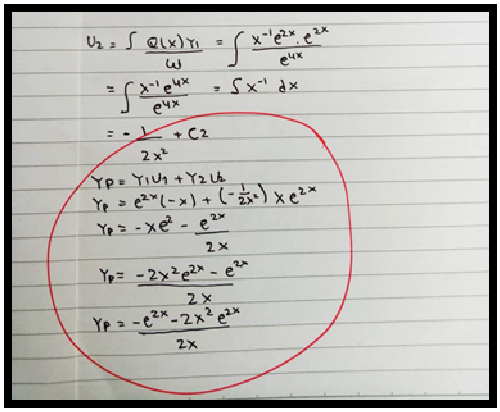

Figure 3. Error Comprehension question from No. 1

The error steps that occur are the same as problem number 1, where the error is done in the comprehension step, namely:

$$Y_p = Y_1U_1 + Y_2U_2$$

$$Y_p = e^{2x}(-x) + \left(\frac{1}{-2x^2}\right)xe^{2x}$$

$$Y_p = xe^{2x} - \frac{e^{2x}}{2x}$$

Where it should be:

$$Y_p = Y_1U_1 + Y_2U_2$$
$$Y_p = -e^{x}.-e^{x} + xe^{2x}$$
$$Y_p = -e^{2x} + xe^{2x}$$

When a step is made wrong, it will not be found from the general solution requested. Furthermore,

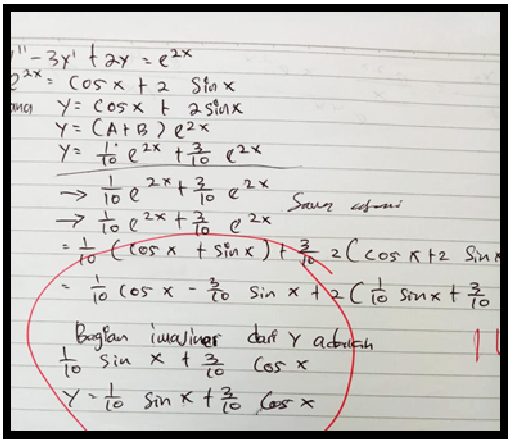

Figure 4. Error Encoding Step from number 1

Figure 4 above explains that, students are wrong in determining the root characteristics. Where:

$$e^{2x} = \cos x + 2\sin x$$
$$y = \cos x + 2\sin x$$
$$y = (A + B)e^{2x}$$
$$y = \frac{1}{10}e^{2x} + \frac{3}{10}e^{2x}$$

Right Steps

$$y'' - 3y' + 2y = 0$$
$$m^2 - 3m + 2 = 0$$
$$(m-1)(m-2) = 0$$
$$m_1 = 1 \;\; atau \;\; m_2 = 2$$
$$Y_h = C_1e^{x} + C_2e^{2x}$$

The biggest mistake that occurs in process errors, this is due to carelessness in the calculation process and the most important is the lack of practice working on questions with varying shapes [re-6], in a hurry to work on so that he does not pay attention to the problems that must be resolved [8,1], less able to identify between a procedure[9]. Furthermore, mistakes in drawing conclusion[10], combining the pictorial information with auditory information would reduce this load and, as a result, would lead to improved performance[11], Students should understand interaction for reversible mathematical processes[12]. By seeing the overall completeness which is only 53.18%, as a teacher should often provide varied exercises, as well as provide contextual modules, so that students can understand the concept of differential understanding.

V. CONCLUSION

From the explanation that has been conveyed that the conclusion in this article is a mistake that is more often the case is a process error, especially in the algebra process in determining the general solution of a problem of differential equations. To that end, as educators, it should often be reminded to be careful in doing calculations, often repeat more varied subject matters and provide contextual modules so that the concept of the subject matters can be understood by students properly and correctly.

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