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RELATIONSHIP BETWEEN STUDENT DIFFERENTIAL AND INTEGRAL CALCULUS LEARNING OUTCOMES TO STUDENT DIFFERENTIAL EQUATIONS LEARNING OUTCOMES

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ABSTRACT

Differential and integral calculus courses are the foundations of mathematics that are important in understanding and applying differential equations. Students can take the Differential Equation course after graduating from the Differential Calculus and Integral Calculus courses. This study aims to determine the relationship between understanding differential and integral calculus and students' learning outcomes of differential equations. The population in this study were all 2020 Pattimura University Teaching and Teacher Training Faculty Mathematics Education students who had taken differential calculus, integral calculus, and differential equations courses, with a total sample of 33 people. The research method used is quantitative research with correlational methods. This study uses multiple regression analysis to find the form and influence between the independent and dependent variables. Based on the results of the data analysis, it was concluded that there was a significant contribution between learning outcomes of differential calculus on learning outcomes of differential equations seen in the relative contribution of learning outcomes of differential calculus on learning outcomes of differential equations based on the calculation results obtained 56.45% while the relative contribution of learning outcomes of integral calculus 43 .54% of the learning outcomes of differential equations. So it shows a significant influence between learning outcomes of differential and integral calculus on learning outcomes of differential equations.

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1. INTRODUCTION

The Differential Equation course is a compulsory subject for students of the Mathematics Education study program at Pattimura University. This course is offered in semester four (IV). The Differential Equation course has a sizeable study weight of three Semester Credit Units (SKS) and is a compulsory subject, meaning that all students are required to take the Differential Equation course. The material discussed is divided into six chapters namely, 1) basic concepts of differential and integral, 2) first-order ordinary differential equations, 3) second-order ordinary differential equations, 4) partial differential equations, 5) vector analysis, and 6) special functions. In chapter one, it discusses differentials starting from terms, basic examples, formulas, equations, rules and practice questions and then continues with integrals, namely the first basic theorem, second basic theorem, types, indefinite integrals, definite integrals, properties, formulas. , methods for finding integrals, applications and practice questions. Chapter two discusses direct integrals, variable separation, exact differentials, integral factor methods, linear differential equations, homogeneous and non-homogeneous differential equations, and Bernoulli's differential equations (Misbah et al., 2020).

Differential Equation is a very important subject not only in the field of mathematics but even for other fields of science because most other fields of science require the application of Differential Equation material. The importance of Differential Equations can be seen from Differential Equations as a prerequisite course for other courses such as Numerical Methods. Furthermore, Differential Equations are used in the fields of economics, physics, biology, civil engineering and various other fields related to the application of various events with the concept of a differential equation. In the economic field, the concept of the Differential Equation is applied to solve the problem of elasticity of demand, marginal, maximum profit, average control model and its relationship to marginal cost (Kustiawati et al., 2022). Even though Differential Equation is a very important subject that must be mastered by students, the facts on the ground show that many students do not complete the Differential Equation course. Research data from Paris & Assidiqi (2014) noted that the average student did not complete at 36.12%, and there were even classes where the percentage of students who failed the Differential Equation course was 50%. The research data was taken for 4 consecutive years.

The Differential Equation course is a conditional course, students are required to have taken the Differential Calculus course offered in the second semester and Integral Calculus offered in the third semester. Differential calculus and integral calculus are the foundations of mathematics that are important in understanding and applying differential equations. Therefore, learning outcomes of differential calculus and integral calculus can affect learning outcomes of differential equations. Differential Calculus and Integral Calculus have the same study load as Differential Equations, namely three (3) Semester Credit Units (SKS). The Differential Calculus course consists of six chapters, namely the real number system; function; limit and continuity; infinity limit; function derivative; use of derivatives (Azizah & Ariyanti, 2018). Differential Calculus is a prerequisite course for several courses other than Differential Equations, namely Integral Calculus and Advanced Calculus (Sumargiyani & Nafi, 2020). The materials discussed in Integral Calculus are indefinite integrals, definite integrals, transcendent functions, integration techniques, and integral applications (Siahaan, 2021). Integral Calculus is very important for students to master because it is a prerequisite course for several courses in the following semester besides the Differential Equations already mentioned. The courses are Advanced Calculus, Mathematical Statistics and Real Analysis (Muhassanah & Lukman, 2021). According to some research results, students' abilities in prerequisite courses, namely Differential

Calculus and Integral Calculus, will affect students' abilities in the Differential Equations course because the material studied in these courses is interrelated and continuous. Students need to understand Integral Calculus material. Students' understanding of Differential Calculus and Integral Calculus material is a reference in mastering Differential Equations material.

Research conducted by Nurlaili & Rifanti (2020) explained that the mistakes that students often make when working on Differential Equations are wrong in determining the integral factor in the initial step so that in the next step it becomes wrong resulting in the final result being inaccurate. The reason students make many mistakes when solving derivative and integral problems is because students do not have an understanding of the concept of integral and derivative material. Sulistyorini, (2017) revealed the results of research conducted on students of the Mathematics Education Study Program at the Budi Utomo Malang Teacher Training and Education Institute, namely that conceptual errors occur when students misunderstand. Students are not able to understand the concepts seen in the problems given, are not in accordance with procedures, and the application is not correct or cannot determine what relationships are in the problem. There are still many students who make mistakes when solving trigonometry derivatives, natural logarithms and exponentials. The results of this study also reveal that students often have difficulty determining solutions to problems related to natural logarithmic integrals, exponential integrals and integral trigonometric functions. The results of the research conducted by Sumargiyani & Nafi (2020) are in line with Nurlaili & Rifanti (2020) and Sulistyorini (2017). The research was conducted on students of the Mathematics Education Study Program, Ahmad Dahlan University, with the aim of analyzing the difficulties encountered when working on material problems of nth-order linear differential equations. The conclusion of the research results is that students are weak in solving problems related to integrals, and derivatives means that students have difficulty in the prerequisite material from the Differential Equation course.

Many studies have been conducted to explore the relationship between the understanding of differential and integral calculus and the results of students learning differential equations. Several studies have shown that students who have a better understanding of differential and integral calculus tend to be more successful in learning differential equations. For example, research conducted by Sari (2022) shows that understanding differential and integral calculus has a significant effect on student learning outcomes of differential equations. This research shows that students who have a better understanding of differential and integral calculus tend to have better learning outcomes in differential equations. Another study conducted by Wahyudi (2018) also showed similar results. This research shows that the understanding of differential and integral calculus has a significant effect on the results of students learning differential equations in a university. Based on the description that has been presented, this study focuses on "The Relationship between Differential Calculus and Integral Calculus Learning Outcomes to Student Differential Equation Learning Outcomes".

2. METHOD

The type of this research is a quantitative research with a correlational method. Quantitative research has data in the form of numbers that can be measured to get a conclusion. Quantitative data is based on concrete data using statistics for calculation test tools (Sugiyono, 2018).). According to Creswell (2014)) correlational research is research using statistical methods to see the relationship between variables in the study. This study uses multiple regression analysis which has the aim of finding the form and influence

between the independent variables and the dependent variable. The independent variable is the result of learning differential calculus (X1) and integral calculus learning outcomes (X2). The dependent variable is the result of learning differential equations. The population in this study were all 2020 Pattimura University Teaching and Teacher Training Faculty Mathematics Education students who had taken differential calculus, integral calculus, and differential equations courses with a total sample of 33 people. The data collection technique uses a documentation study, namely data taken from student siakad data including final grades in differential calculus, integral calculus, and differential equations courses.

Data analysis technique using multiple regression test. Sudarmanto (2005) revealed that a multiple linear regression model can be called a good model that has accuracy in estimation, is not biased and is consistent if it fulfills the assumption of normality and is free from classical assumptions. Ghozali (2009) further states that the multiple regression test requires prerequisite tests first, namely the normality test, linearity test, multicollinearity test, autocorrelation test, and heteroscedasticity test. All statistical analyzes used the SPSS 24 application. In this study, calculations were made of the effective contribution and the relative contribution of each independent variable.

3. RESULTS AND DISCUSSION

3.1. Results

Data on learning outcomes of differential calculus, integral calculus and differential equations are presented in Table 1 below.

Table 1. Learning Outcomes of Differential Equations, Differential and Integral Calculus

	Learning outcomes		
	Differential Calculus	**Integral Calculus**	**Equations Differential**
The highest score	93.34	92.50	80.00
The lowest score	41.35	36.03	21.00
Mean	66.1555	65.0865	53.3161
Median	65.60	64.12	50.05
Standard Deviation	13.32214	15.88567	15.37309

Based on Table 1, it is known that the highest learning outcomes are successively for the three subjects, namely differential calculus which is the highest compared to the highest learning outcomes in integral calculus and finally the learning outcomes of differential equations. The lowest score for the lowest learning outcomes is in the differential equations course compared to integral calculus and differential calculus. The same thing also happens to the mean and median, the mean and median values of the differential equation are lower in comparison two other courses respectively namely integral calculus and differential calculus. But for the standard deviation, the highest is the standard deviation of the integral calculus then the differential equation and the lowest is the standard deviation of the differential calculus. Before carrying out data analysis using multiple linear regression tests, a prerequisite test of multiple linear analysis was carried out first. The first test to be carried out is the normality test, namely the Liliefors test which is presented in Table 2.

Based on Table 2, it is obtained that the significance values of Asymp Sig (2-tailed) for differential calculus, integral calculus, and differential equations are 0.806, 0.364, and 0.438 respectively, which are greater than the value of α = 0,05 so that it can be concluded that the data on the learning outcomes of the three courses are normally distributed.

Table 2. Liliefors Test

	Shapiro Wilk		
	Statistic	df	Sig.
Differential Calculus	.980	31	.806
integral calculus	.964	31	.364
Differential Equation	.967	31	.438

a. Lilliefors Significance Correction

The results of the multicollinearity test are shown in Table 3. Basis for decision making for tolerance multicollinearity tests and VIF according to Imam (2011) there are no symptoms of multicollinearity if the tolerance value is more than 0.1 and the VIF value is less than 10.00.

Table 3. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-5.905	8.689		-.680	.502		
	KALDIF	.542	.238	.470	2.277	.031	.293	3.414
	KALINT	.359	.200	.371	1.800	.083	.293	3.414

Based on Table 3, the tolerance value of differential calculus and integral calculus is 0.293 more than 0.05 and the VIF value is 3.414 less than 10.00 so that the conclusion is that there are no symptoms of multicollinearity or there is no strong relationship (correlation) between the independent variables, namely the results of learning calculus differential and integral calculus. The heteroscedasticity test using the Glejser test is shown in Table 4.

Table 4. Glejser Test

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	14.274	5.352		2.667	.013
	KALDIF	-.229	.147	-.519	-1.559	.130
	KALINT	.118	.123	.318	.957	.347

a. Dependent Variable: Abs_Res

Table 4 shows that the value of sig. differential calculus is 0.130 more than 0.05 and the integral calculus sig value is 0.347 more than 0.05, there is no heteroscedasticity problem. Furthermore, the Durbin Watson autocorrelation Stest was carried out. Imam (2011) has no symptoms of autocorrelation if the Durbin Watson value lies between the values du to (4-du). The du value is obtained from the distribution of values in the Durbin Watson table based on k = 2 (number of independent variables) and n = 31 (number of samples) with a significance of 5%. From the table obtained du = 1.570 and 4-du = 2.43.

Table 5. Durbin Watson Test

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.807[a]	.651	.626	9.39676	1.653

a. Predictors: (Constant), KALINT, KALDIF

b. Dependent Variable: PD

Table 5 shows the Durbin Watson value is 1.653 so that du (1.570) < 1.653 < 4-du (2.43) means that there are no symptoms of autocorrelation. Furthermore, an analysis was carried out with the F test and T test to determine the contribution of learning outcomes of differential calculus and integral calculus to learning outcomes of differential equations, the contribution of learning outcomes of differential calculus to learning outcomes of differential equations, and the contribution of learning outcomes of integral calculus to learning outcomes of differential equations. The F test was conducted to see the contribution of learning outcomes of differential calculus and integral calculus to learning outcomes of differential equations simultaneously.

Table 6. F Test

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	4617.582	2	2308.791	26.147	.000[b]
	Residual	2472.375	28	88.299		
	Total	7089.957	30			

a. Dependent Variable: PD

b. Predictors: (Constant), KALINT, KALDIF

The results from table 6 can be concluded that:

Contribution of Differential Calculus and Integral Calculus Learning Outcomes to Differential Equation Learning Outcomes

The significance value (Sig) of learning outcomes of differential calculus and integral calculus is 0.00 less than 0.05 so that the conclusion obtained is that there is a significant effect between learning outcomes of differential calculus and integral calculus on learning outcomes of differential equations.

The results of the linearity test obtained that there was a significant linear relationship between the independent variables namely learning outcomes of differential calculus and integral calculus with the dependent variable, namely learning outcomes of differential equations. Based on the results of the prerequisite test for multiple linear regression analysis, namely the normality test, linearity test, multicollinearity test, autocorrelation test, and heteroscedasticity test, it can be concluded that the multiple linear regression test is good to do.

Table 7. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constan)	-5.905	8.689		-.680	.502		
	KALDIF	.542	.238	.470	2.277	.031	.293	3.414
	KALINT	.359	.200	.371	1.800	.083	.293	3.414

Based on the results from SPSS according to Table 7 the regression model can be

written as follows:

$$Y = -5{,}905 + 0{,}542X_1 + 0{,}359X_2$$

Information:
Y = learning outcomes of differential equations
X_1 = learning result of differential calculus
X_2 = integral calculus learning outcomes

Table 8. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.807[a]	.651	.626	9.39676

a. Predictors: (Constant), KALINT, KALDIF

b. Dependent Variable: PD

Table 8 shows the value of the coefficient of determination (R^2) reached 0.651 which can be interpreted that the contribution of the influence of differential calculus and integral calculus learning outcomes simultaneously (simultaneously) on the learning outcomes of differential equations that is equal to 65.1%, while the remaining 34.9% is influenced by other variables besides learning outcomes of differential calculus and learning outcomes of integral calculus. The sum of the values of the coefficient of determination (R^2) is equal to the sum of the effective contributions of the differential calculus and the effective contributions of the integral calculus. Effective contribution (SE) is a measure used to determine the amount or magnitude of the contribution of an independent variable to the dependent variable in the regression analysis. The relative contribution (SR) is a measure used to determine the amount or magnitude of the contribution of an independent variable to the determination (R^2). The sum of all the relative contributions of all independent variables is 100% or 1.00.

Table 9. Correlation and Regression Analysis Results

Variabel	Koefisien Regresi Beta	Koefisien Korelasi (r)	R^2
X_1	0,470	0,782	0,651
X_2	0,371	0,766	

Based on Table 9, it is obtained that the effective contribution of differential calculus learning outcomes to differential equation learning outcomes reaches 36.75% while the effective contribution of integral calculus learning outcomes is only 28.35% to differential equation learning outcomes. This shows that learning outcomes of differential calculus have sa greater influence on learning outcomes of differential equations. Furthermore, the relative contribution of learning outcomes of differential calculus to learning outcomes of differential equations based on the calculation results obtained 56.45%, while the relative contribution of learning outcomes of integral calculus is smaller, only 43.54% of learning outcomes of differential equations. Furthermore, an analysis was carried out with the T test to determine the contribution of learning outcomes of differential calculus to learning outcomes of differential equations, the contribution of learning outcomes of integral calculus to learning outcomes of differential equations. The results of the partial t test can be seen in table 10.

Table 10. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constan)	-5.905	8.689		-.680	.502		
	KALDIF	.542	.238	.470	2.277	.031	.293	3.414
	KALINT	.359	.200	.371	1.800	.083	.293	3.414

Based on table 10, several conclusions are obtained, namely:

1. Contribution of Differential Calculus Learning Outcomes to Differential Equation Learning Outcomes

The significance value (Sig) of differential calculus learning outcomes is 0.031 less than 0.05 so that the conclusion obtained is that there is a significant effect between differential calculus learning outcomes on differential equation learning outcomes if the integral calculus learning outcomes variable is included in the model

2. Contribution of Integral Calculus Learning Outcomes to Differential Equation Learning Outcomes

The significance value (Sig) of learning outcomes of integral calculus is 0.083 more than 0.05 so that the conclusion obtained is that there is no significant effect between learning outcomes of integral calculus on learning outcomes of differential equations if the variables of learning outcomes of differential calculus are included in the model.

3.2. Discussion

Differential Equations are one of the most important topics in mathematics and also in other fields because they are widely used in physics, engineering, and computer science. Students need to understand Differential Equation material in order to be successful in other courses that have Differential Equation as a prerequisite course. But the majority of students have difficulty learning differential equations. Student scores in the Mathematics Education Study Program FKIP UNPATTI who contracted the Differential Equation course in 2019 are still very low, far from satisfactory. Of the 35 students who attended the lecture, 24 of them were only able to get a D and one person even got an E. This means that more than half of the students do not understand Differential Equations. This is in accordance with research conducted by Khasanah (2018) that the ability of Mathematics Education students at UIN Raden Intan Lampung in the Differential Equation course is still low. Some research results reveal that students make many mistakes when solving Differential Equation problems because students do not understand concepts, principles, or operations related to integration or differential (Fauziah, 2019), (Sulistyorini, 2017), (Rejeki & Setyaningsih, 2016), (Saparwadi, 2018).

Students' abilities in the Differential Equation prerequisite courses, namely Differential Calculus and Integral Calculus have a significant contribution to the results learn Differential Equations.Yanti (2017) stated that the final score of Differential Calculus or Calculus 1 and the final score of Integral Calculus or Calculus 2 simultaneously contributed to the final Differential Equation score of 34.70 percent. Therefore, a good understanding of differential and integral calculus is needed by students in learning differential equations. In the opinion of Nursalam et al., (2014) there is an effect of mastery of prerequisite material on learning outcomes. This research was conducted on students who contracted the Differential Equation course in the even semester of the 2021/2022 academic year. The result

of the research is that there is a significant influence between learning outcomes of differential calculus on learning outcomes of differential equations. This result is different from the results of learning Integral calculus on learning outcomes of differential equations, namely there is no significant effect. However, for the effect of the prerequisite material simultaneously or together, it was found that there was a significant effect between learning outcomes of differential calculus and integral calculus on learning outcomes of differential equations. The results of this study are supported by previous research conducted by Rejeki & Setyaningsih (2016) namely the partial contribution of Differential Calculus, Integral Calculus to Differential Equations respectively 62% and 38%. For the simultaneous contribution of the two prerequisite courses it reached 63%.

4. CONCLUSION

Based on the results and discussion, there are several conclusions that can be drawn in this study, namely: (1) there is a significant contribution between learning outcomes of differential calculus on learning outcomes of differential equations, (2) there is no significant contribution between learning outcomes of integral calculus towards learning outcomes of equations differential, (3) there is a significant contribution between learning outcomes of differential calculus and integral calculus towards learning outcomes of differential equations. Some suggestions based on the results of this study are (1) students must have good skills in differential calculus and integral calculus courses because they have a very strong influence on differential equation learning outcomes, (2) lecturers must choose a learning model that can improve learning outcomes in differential equations course.

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