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THE INFLUENCE OF THE BASIC CALCULUS APPROACH TO LEARNING OUTCOMES

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Abstrak

Tujuan penelitian ini adalah untuk melihat pengaruh pendekatan kalkulus dasar terhadap hasil belajar fisika dasar. Latar belakang penelitian ini didasarkan rendahnya pemahaman siswa terhadap analisis fisika dasar. Pendekatan ini digunakan karena kalkulus dasar dapat mengidentifikasi dan menganalisis zat fisik dasar melalui bahasa diferensial dan integral yang terdapat dalam kalkulus dasar. Sampel penelitian ini adalah mahasiswa jurusan pertambangan Institut Sains dan Teknologi, TD.Pardede Medan dan mahasiswa jurusan Fisika Universitas Sumatera Utara yang dijadikan kelompok sampel. Metode penelitian yang digunakan dalam penelitian ini adalah Quasi-eksperimental one group design. Untuk melihat hasil belajar digunakan tes hasil belajar dan tes gain untuk meningkatkan hasil belajar. Hasil penelitian menunjukkan bahwa terjadi peningkatan gain pada setiap pertemuan tinggi, disimpulkan bahwa manfaat strategi pembelajaran berbasis masalah dengan pendekatan kalkulus dasar dapat meningkatkan hasil belajar siswa.

Kata Kunci: *pendekatan kalkulus, fisika dasar, kalkulus dasar, hasil belajar*

I. INTRODUCTION

Basic physics is one of the scientific studies that is analytic, both analytical in logic and in terms of mathematics. The close relationship between mathematics and the concepts of physics is like two sides of a metal eye that are inseparable. The use of mathematical analysis skills in analyzing problems in basic physics and applied physics is largely determined by students' understanding of basic calculus techniques.

Currently, research on science learning is an important indicator in realizing the progress of a country's education system. (Civelek, T et al, I, 2013) explained that technological progress is currently very fast and rapid in all lines of life, including in the field of education. Physics learning research is one that is widely developed because many technologies are developed by the interpretation of laws and physics concepts. However, learning physics is difficult to reduce the interest of learners to give time to learn the concepts of physics itself. Physics learning is often felt by students and students as difficult learning and this is not unreasonable. This is because physics learning is complex learning, meaning that physics deals with formulas, algebraic structures, number operations and even abstract concepts from mathematics. As a result, students need more time and reflection to absorb the basic ideas of physics concepts. At the university level, learning physics is very different from the high school level. At the university level, the analysis of physics concepts has a lot to do with calculus, where at the high school level it does not yet exist because the concept of calculus is inadequate. The difficulty of students has increased because the concept of physics is integrated with the concept of calculus (Nguyen & Rebello, 2011). Even the dominance of calculus is so influential that it appears that mathematics is the language of physics.

Students' difficulties with basic calculus

In fact, there is a close relationship between physics and mathematics so that mathematical proficiency is needed to understand the concepts of physics in mathematical models (Kereh, Liliasari, et al 2014). In physics, mathematics places a major role in its ability to solve physics problems from the simplest form to the most complex, this we can see because mathematical equations appear very much in the concept of physics. for example to calculate the total amount of charge contained in a material we need to define very small parts then we add up (integratiton) these parts to a certain extent.

Based on the background above, the problem of this study is : firstly, Does the problem-based physics learning strategy with a basic calculus approach in the Basic Physics subject improve learning outcomes. Secondly, Is there a close relationship between Elementary physics and elementary calculus.

Table 2. Percentage Assessment of Learning Strategies

No	Assessment	%	Interpretation
1	The Objectives of Learning Strategies	83%	Very feasible
2	Learning Organization	83%,	Very feasible
3	Learning Process	85%	Very feasible
4	Learning Media	85%	Very feasible
	Average of all stages	84%	Very feasible

This study aims to obtain a high increase in learning outcomes through a problem-based learning process. The hypothesis of this research is that physics learning strategies in Basic Physics courses can improve learning outcomes and problem-based physics learning strategies in Basic Physics courses.

II. RESEARCH METHODS

The samples of this study were students majoring in mining ISTP Medan and students majoring in physics, University of North Sumatra, TA 2020/2021 who were made into one sample group. When this research was conducted for one year from January to November. In this study, the method used to determine student learning outcomes is the Quasi Experiment method with one group design pretest and posttest techniques. The pretest is carried out to see the mastery of the initial concept and the posttest is used to determine learning outcomes after using problem-based learning strategies with the calculus approach.

Broadly speaking, this research is grouped into two (2) major parts, namely the first starting with Needs Analysis and making teaching materials and the second is the application and evaluation to students. In the first stage, the analysis of needs and the manufacture of teaching materials is made using the 4D model (Thiagarajan, 1974) by defining (Define) the basic concept of making teaching materials. Teaching materials are made (Design) based on problems with the basic calculus approach (Differential and Integral). The materials chosen are Thermodynamics and Magnetic Electricity. After the teaching materials are made, then the teaching materials are evaluated (Develop) by the Expert (Validator) and after that they are tested (Disseminate). In the second stage, evaluation of learning outcomes in the form of posttest, posttest data analysis and Gain analysis and conclusions is carried out.

The technique in analyzing the pretest and posttest data is the analysis of the gain value (Gain Score). Analysis of the gain value is to calculate the increase in the score from the posttest due to the learning strategy. The level of improvement in learning outcomes in the form of gain is shown in table 1 (gain index interpretation). Equation (1) is the formula for calculating the gain value:

$$N\ gain = \frac{(\text{Posttest Score} - \text{Pretest Score})}{(\text{Ideal Score} - \text{Pretest Score})} \quad (1)$$

table 1: gain index interpretation

Gain Score	Interpretation
$g \geq 0{,}7$	High
$0{,}3 \leq g < 07$	Medium
$g < 0{,}3$	Low

III. RESULTS AND DISCUSSION

Research result

The research results are grouped into two parts, namely the results of the responses of lecturers and students and student learning outcomes. The results of this study are used to see the effect of applying problem-based learning strategies with the basic calculus approach on the results of basic physics learning.

1. Student response.

The results of the research in the form of responses by lecturers and students are used to see the suitability and accuracy of learning strategies to improve learning outcomes. This response was tested through the Lecturer analysis of the learning strategy material and the basic calculus substance on the development and analysis of the relationship between physics and basic calculus. Student assessment of learning strategies in the form of questions about the Objectives of Learning Strategies, Learning Organization, Learning Process and Learning Media. The research data regarding the response to the learning strategy, namely the strategic objectives, was obtained by 83%, regarding the Learning organization it was obtained about 83%, Regarding the Learning process it was

obtained as much as 85% and regarding the Learning Media it was obtained around 85%.
Table 2 is percentage Assessment of Learning Strategies with interpretation.

2. Student Learning Outcomes

Student learning outcomes are the level of student mastery of something that is obtained in a learning process through evaluation. Learning outcomes are useful for determining the level of success achieved by students after participating in a learning activity. Learning outcomes can be seen from the test results of basic physics learning materials in the form of conceptual questions related to basic calculus. The learning outcome test is given in three main subjects, namely heat conductivity, thermodynamics and electric fields. The research data showed that for the first meeting, the average pretest result for the heat conduction material was 23.92 and the posttest average result was 77.91. From these data, it is obtained a gain of 0.67 with an analysis of the gain obtained is in the Medium category.

The research data showed that for the second meeting, the average pretest result for the thermodynamics material was 17.42 and the posttest average result was 82.17. From these data, it is obtained a gain of 0.71 with an analysis of the gain obtained is the High category. The research data showed that for the third meeting, the average pretest result for the Electric Field material was 39.42 and the posttest average result was 91.58. From these data, a gain of 0.78 was obtained with an analysis of the gain obtained in the High category. In the table 3 shown the average of pretest and posttest

Table 3. Average of pretest and posttest

Meeting	Average		$N\ gain$	Catagories
	Pretest	Posttest		
I	23,92	77,91	0,67	Medium
II	17,42	82,17	0,71	High
III	39,42	91,58	0,78	High

This gain analysis was conducted to determine the increase in students' abilities in basic physics from the results of the pretest and posttest data obtained at each meeting. This means that each meeting is given a test in the form of a pretest and posttest then analyzed the gain test. From the table above, a graph can be made of the increase in student learning outcomes after using problem-based learning strategies.

In addition to improving learning outcomes from the graph, it is also obtained an increase in the average gain in learning outcomes.

Discussion of Research Results

Assessment of the application of problem-based learning strategies with the basic calculus approach in this study is seen from two things, namely direct assessment by lecturers and students in the form of an assessment questionnaire of learning strategies. For the assessment of the learning strategy objectives, a percentage of 88% is obtained, this indicates that there is suitability and accuracy in formulating problems, increasing motivation and learning outcomes after using learning strategies. For the assessment of learning organizations, a percentage of 85% is obtained, this shows that there is suitability and accuracy in linking the process of formulating problems with problem solving, linking process skills with learning outcomes through the basic calculus approach and problem-based skills with basic calculus. For the assessment of the learning process, a percentage of 87% is obtained, this indicates that there is a link between process skills, scientific methods using the basic calculus approach. For the assessment of learning media, a percentage of 88% is obtained, this indicates that the use of problem-based learning media with the calculus approach can improve the process. learning which in turn improves learning outcomes.

From the data from the study test results, it was found that at the first meeting with the heat conduction material, a learning outcome gain was 0.67 which in this case the increase in learning outcomes was moderate, which meant that students adapted to problem-based learning strategies. At the second meeting with thermodynamic material Obtained a learning outcome gain of 0.71 which means that the increase in student learning outcomes is high due to the application of problem-based learning strategies with the basic calculus approach. In the third meeting with the electric field material, the learning outcome gain was 0.78 which means that the increase in student learning outcomes was high due to the application of problem-based learning strategies with the basic calculus approach. The average gain in learning outcomes from the three meetings was 0.72, which means

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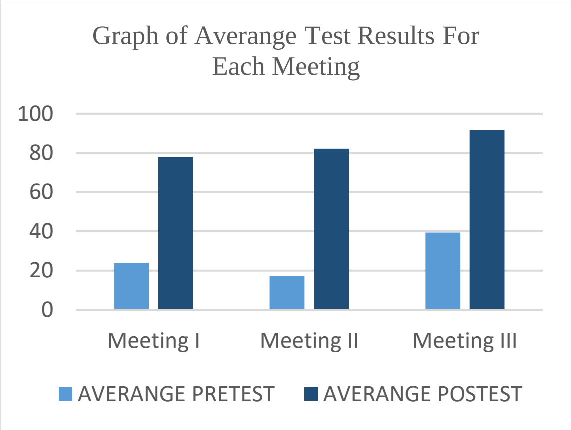
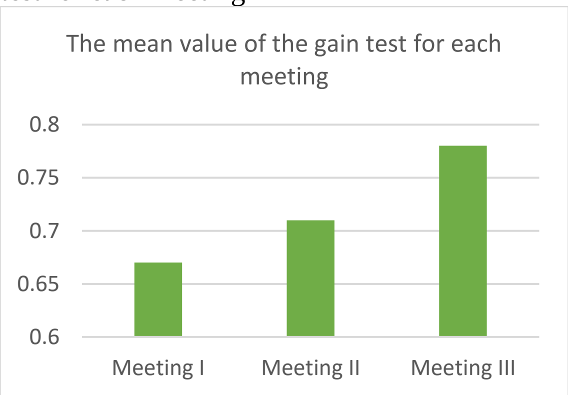
that overall the use of problem-based learning strategies with the basic calculus approach can improve student learning outcomes. In the Picture 1 shown the graph of Average Test Results for Each Meeting.

Picture 2. Graph of Average Test Results for Each Meeting



The mean value of the gain test as the result of the total number of gain test results from all students divided by the number of students. In the Picture 2 shown the graph of the mean value of the gain test for each meeting.

Picture 2. Graph of the mean value of the gain test for each meeting



Relationship between Basic Calculus and Basic Physics

In general, student achievement in the field of basic physics and calculus has a low success rate (Caroline Ferguson, 2016). This is related to the main weak basic concept which later becomes a tool to develop advanced science. Several previous studies have also shown that the result of the unsynchronized learning between calculus and basic physics is an inhibiting factor for student learning outcomes. Some terms are used such as mathematics as a tool to be able to solve physics problems, because in reality physics is inseparable from mathematical calculations such as adding, subtracting, multiplying, differentiating, integrating and so on. For example, deepening understanding of the concept of kinematics requires mathematical skills to find physical quantities, namely differential and integral (Haryadi, 2015). (Quale, 2011) said that to represent the scientific laws used and to investigate the consequences of laws in physics and its various branches of science, mathematical formulations are needed so that the relationship between mathematics and physics cannot be separated. Therefore, to be able to master physics, one must be able to master mathematics first so that the problems contained in physics content can be solved easily. Physics is a part of science that has a correlation with mathematics.).

The basis of the relationship between basic calculus and basic physics is that there are similarities in cognitive analysis (scientific studies) between the two. Basic physics which describes physical state problems at the miscroscopic and macroscopic levels can be explained by the basic calculus language in the form of differentials and integrals. Differential integration is used in many physics problems and for broader solutions. Developing the skills to use basic calculus in physics is necessary Preparing integrals in physics problems can be broken down into several steps: preparing expressions for very small quantities (for example, dE, dB), aggregating infinitesimal quantities, determining integration variables, and converting integrals to biased form is evaluated mathematically. For example $E = k\frac{q}{r^2}$ becomes $dE = k\frac{dq}{r^2}$ which will be integrated to get a solution.

Differentiation

Variables such as ∂x, ∂r, $\partial \Psi$ or ∂E in physics have become a physical quantity that is analytical because they can explain the state of a predictable physical system. The expression of the infinitesimal term ∂x (infinitesimal) implies that the element of the quantity is present in the dimensions of time and space. The symbol ∂ is used to differentiate a function such as

$$df(x) = f'(x)dx.$$

Some physical quantities expressed as very small kecil x (infinitesimal) are listed in the table 4 below.

Table 4. Physical quantities in differential form

PHYSICAL QUANTITIES	DIFFERENTIAL FORM (INFINITESIMAL)	EQUATION
Charges (q)	∂q	$\partial q = \lambda\, \partial L$
Electric Current (i)	∂i	$\partial i = Q \partial t$
Electric Field (E)	∂E	$\partial E = \frac{k}{r^2} \partial q$
Temperature (T)	∂T	$\partial T = \frac{H}{kA} \partial L$
Heat (Q)	∂Q	$\partial Q = \partial U - \partial W$
Area (A)	∂A	$\partial A = \partial x \partial y$

Integration

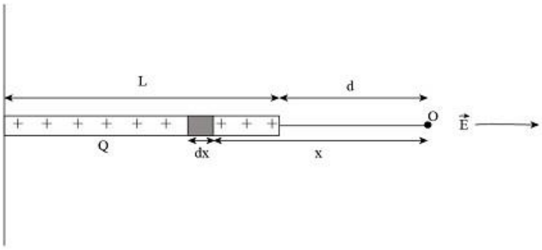
The idea of integration (integral) is Reinman integration, which is cutting the parts into infinitesimal and then adding them. So it can be said that the integral is anti-differential. The result of integration is the new physical quantity that we formulate after taking the smallest part. For example from picture 3, calculating the total charge of a rod along L with charge density $\lambda = \frac{dq}{dx}$ that we get the total charge (Q) along the length of the rod by integrating along L.

$$dq = \lambda dx$$

$$\int dq = \int_0^L \lambda\, dx$$

$$Q = \lambda L$$

Pictures 3 : Charged rod along L



This result shows that regardless of the length of the charged rod, the total charge contained in the linear rod with the length of the rod.

IV. CONCLUSION

The conclusion of this research is obtained from the research data. the presentation system is carried out by taking into account the research objectives that have been formulated. the conclusions obtained are that there is an increase in student learning outcomes as indicated by the results of the gain test with the average gain in learning outcomes from the three meetings increasing. So it can be concluded that problem-based strategy learning with the basic calculus approach can improve student learning outcomes in basic physics courses.

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REFERENCES

Aslihan, K., & Mustafa, B. (2014). *The Effect of Problem Based Learning Approach on Conceptual Understanding in Teaching of Magnetism Topics*. Eurasian Journal of Physics & Chemistry Education. P 110-122.

Civelek, T., Ucar, E., Gokcol, O.,Ustunel, H., & Umit, I. (2013). *The effects of computer assisted physics experiment simulations on students' learning*, Cypriot Journal of Educational Sciences.

Dehui Hu and N. Sanjay Rebello (2013). *Understanding student use of differentials in physics integration problems*. Physics Review Special Topics. https://doi.org/10.1103/PhysRevSTPER.9.020108.

Dong-Hai Nguyen and N. Sanjay Rebello (2011), *Students' difficulties with integration in electricity*. Physics Review Special Topics. https://doi.org/10.1103/PhysRevSTPER.7.010113.

Gaber, H & El – Shaer, A. 2014. *Impact of Problem Based Learning on Students' Critical Thinking Dispositions, Knowledge Acquisition and Retention*. Journal of Education and Practice.

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Volume 3 No. 2 Juli 2023

Hartono. (2013). *Learning Cycle-7E Model to Increase Student's Critical Thinking on Science*. Indonesian Journal of Physics Education,JPFI, 9 (1),p. 58-66.

Heris Hendriana, Tri Johanto, Utari Sumarmo, (2018) *The Role Of Problem-Based Learning To Improve Students Mathematical Problem Solving Ability And Self Confidence*. Mathematics Education Journal,(JME) pp. 291-300

Kereh, Liliasari, P. C. Tjiang, J. Sabandar (2014). *The Correlation Between Students Mastery On Basic Mathematics And Their Matery On Introductory Nuclear Physics*. Indonesian Journal of Physics Education, (140-149).

Majed Saleem Aziz, Ahmad Nurulazam Md,Zain Mohd Ali Bin Samsudin dan Salmiza Binti Saleh (2014). *The Effects of Problem-Based Learning on Self-Directed Learning Skills among Physics Undergraduates.* International Journal of Academic Research in Progressive Education and Development.

Rusman. (2010). *Learning Models* (Developing Teacher Professionalism Second Edition). Jakarta: Raja Grafindo Persada.

Syamsuri, Indiana Marethi & Anwar Mutaqin.(2018). *Understanding on Strategies of Teaching Mathematical Proof for Undergraduate Students*. Cakrawala Pendidikan Journal. https://doi.org/10.21831/cp.v37i2.19091

Tipler, P. A., Mosca G., (2007). *Physics for Scientists and Engineers*. New York : W. H. Freeman.