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ENGINEERING PHYSICS FIRST-YEAR STUDENT ASSESSMENT: A CASE STUDY ON BASIC PHYSICS 2 LABORATORY REPORT WRITING SKILLS

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Abstrak

Latar Belakang: Teknik dan Perakayasaan telah memainkan peran penting dalam aktivitas manusia melalui perkembangan teknologi dan Revolusi Industri. Pentingnya peran insinyur menunjukkan kebutuhan akan lulusan profesional yang memenuhi tuntutan global. Dengan demikian, pendidikan teknik yang terstandarisasi sangat penting. Selain aspek teknis, kemampuan non-teknis seperti menulis juga sangatlah penting, terutama bagi mahasiswa tahun pertama. Objektif: Maka dari itu, penelitian ini dilakukan untuk menganalisis penulisan laporan mahasiswa teknik tahun pertama khususnya untuk jurusan teknik fisika UMN pada mata kuliah Fisika Dasar 2 Laboratorium. Metode: Metode yang digunakan adalah kualitatif melalui studi kasus pada empat individu melalui 10 modul yang mana laporannya akan dibandingkan dengan penilaian rubrik dari pengajar. Hasil dan Pembahasan: Hasil menunjukkan pemahaman dan kinerja yang cukup tentang topik dan aspek penulisan meskipun masih memerlukan penjabaran lebih lanjut dalam penyelesaian data dan analisis kritis untuk memastikan improvisasi karena efikasi diri dan konsep diri partisipan dianggap rendah. Temuan ini menekankan akan pentingnya menulis laporan yang terstruktur dan baik serta dapat digunakan sebagai referensi untuk penelitian selanjutnya. Rekomendasi: Rekomendasi bagi mahasiswa dari tahap persiapan hingga evaluasi diberikan untuk membangun konsep diri dan efikasi diri yang positif.

Kata Kunci: Teknik dan perakayasaan, penulisan laporan, Fisika Dasar 2, konsep diri, efikasi diri

Abstract

Background: Engineering has played an important role in human activities through technological development and the Industrial Revolution. The significance of engineers conveys the need for professional graduates who comply with the world's demands. Thus, engineering education that fulfills certain standards is crucial. Aside from the technical aspect, non-technical abilities such as writing are similarly fundamental, especially for first-year students. Objective: Thus, this research is conducted to analyze the report writing of the first-year engineering students particularly for the engineering physics department of UMN in Basic Physics 2 Laboratory course. Method: The qualitative method is used for a case study on four individuals, and their reports on 10 different modules are compared with the rubric assessment given by the lecturer. Results and Discussion: Results show sufficient understanding and performance of the topic and writing aspect though additional notes for further elaboration in data completion and critical analysis are needed to ensure improvement as their self-efficacy and self-concept is considered low. These findings emphasize the importance of writing a well-structured report and act as references for similar future studies. Recommendations: Preparation to evaluation stages are given to build positive self-concept and self-efficacy.

Keywords : Engineering, report writing, Basic Physics 2, self-concept, self-efficacy

INTRODUCTION

The importance of engineering in the modern world is shown through the advancement of technologies that have eased human activities decade by decade. The industrial revolution, which is currently in rapid development within many fields including sciences, manufacturing, communications, politics, entertainment as well as education industries, has relevantly made the integration of science, technology, engineering, and mathematics (STEM) applicable (Hafni et al., 2020). In relation, the role of engineering education has gained prominence as it can improve an individual's scientific knowledge of practical problems (Simarro & Couso, 2021). For instance, successful new product development (NPD) relies on the knowledge exchange approach between engineers and designers to ensure its feasibility while meeting the market requirement (Hur et al., 2024). Thus, engineering incorporation in various fields is compulsory to push technological improvement.

The demand for professional engineers is very high but youngsters nowadays are not attracted to pursuing these majors (Johnson & Ramadas, 2020). In addition, recent studies suggest that STEM majors still face challenges in engagement and procurement (Sperling et al., 2024). In the sense of this, engineering student recruitment and retention become especially significant (Pacher et al., 2024). For example, a research by the German Economy shows an increasing demand for specifically by 48,300 engineers and 68,800 STEM academics between 2023 and 2028 yearly (Christina et al., 2020). These findings highlight the significance of training to address the gap in engineering requirements which can be done through training and education.

The need for proper engineering education is deemed as a future investment that fulfills the competitiveness and sustainability aspect in the context of technological and innovative solutions (Pacher et al., 2024). In detail, engineering education may consist of lectures, seminars, workshops, tutorials, laboratory, elective courses, self-learning courses, projects, etc (Johnson & Ramadas, 2020). The high structure and standard of the engineering curriculum involve programs to fulfill the understanding while also including nontechnical considerations such as user needs, business, and sustainability in the concept of products for modern society (Miska et al., 2022).

Engineering majors are also divided according to the specific branches that will comply with targeted requirements through facilitated education in institutes. One of the branches is called engineering physics. Engineering physics is a study program that covers topics related to technology and physics (ITB, 2023). Sometimes people are mistaken that Physics and Engineering physics are the same, but these study programs have quite major differences. Physics majors are usually more directed on Mathematics and Natural Science study by learning theoretical basis on science, while Engineering physics study program focuses on analyzing various engineering issues from the aspect of physics (SEO, 2022a). The scope of expertise of this major is quite large ranging from construction, renewable energy, manufacturing, and other various engineering experts such as electronics or systems (SEO, 2022b). Students of Engineering physics will usually take diverse classes including elementary physics, engineering mathematics, basic chemistry, electronics, etc.

Engineering physics, specifically in Indonesia, can be enrolled in several universities, one of which is available at Universitas Multimedia Nusantara (UMN). UMN is a university located in Gading Serpong and comprises several buildings: the A, B, C, and D Towers. The university is known for its commitment to green building principles, notably showcased in its New Media Tower (C) and PK Ojong Tower (D). Established in 2016 under the Faculty of Engineering and Informatics, UMN has set three specializations for Engineering physics which are energy management, building physics, and instrumentations. The curriculum is composed of ensuring that graduates receive appropriate skills and knowledge before proceeding to the professional engineering world. Thus, it includes several important courses under the category of math and natural sciences, engineering core as well as general education.

One of the courses that first-year students specifically must participate in is Basic Physics 1 and 2. The first, in the case of UMN, emphasizes classical mechanics while the further concentrates on electronic fundamentals. These courses serve as the introduction for the succeeding advanced courses, making it equally important to the overall understanding of engineering and science by students. The course is divided into two main classes which are theory and laboratory aspects. Both require writing tasks which will be used as the basis for lecturers to know the understandings of students. Laboratory report writing, for instance, is an important aspect that needs to be studied to identify the possibility of improving first-year engineering students' writing ability.

One of the most important skills that first-year students should develop is writing. Writing is defined as a combination of

management of cognitive, motivational, and linguistic processes (Mendoza et al., 2022). In the case of university, students are required to paraphrase, arguments, sources, and target adaptation according to the discipline. Writing involves two self-factors which are self-concept and self-efficacy. Self-concept is the evaluation or perception of oneself in the range of general to specific domains, formed by experiences and responses. Whereas self-efficacy means a perception of capability to perform specific tasks, stemming from mastery experiences, vicarious experiences, verbal persuasion, and emotional states. Both factors are influenced internally and externally which are associated with writing performance.

In a particular way, writing for engineers becomes underrated because students who choose this major wish to focus on mathematical and practical work instead (Selwyn & Renaud-Assemat, 2020). This creates a gap in writing communication although students believe this to be similarly important. Another factor is that they have no self-confidence along no clear knowledge of good writing skills. With regards, however, professional engineers must be able to communicate effectively, including writing technical reports. Thus, it is important to impart and teach these soft skills to engineering students. One of the solutions is to give feedback from the assessor to the students with the intention of improving.

Aside from studies on writing, prior studies on first-year engineering students are not often conducted with some mainly discussing their performance and results. A study presents an approach to reflection and feedback towards 300 first and second-year engineering students in the case of technical reports (Selwyn & Renaud-Assemat, 2020). The results show that students were positive

on the specific feedback which encouraged the development of self-regulation skills.

Another study examined three indicators by learning, assessment, and challenges on students for the remote teaching and learning approach (Basitere et al., 2023). The results show student's learning and performance in mathematics (calculus) courses at a chosen university, the University of Technology in South Africa which suggest several improvements such as careful planning by lecturers and shows the need for curriculum organization for learning activities as a result of limited resources.

Last but not least, a study analyzes first-year university students' conceptions of their second language (L2) self-concept and self-efficacy in English academic writing (Mendoza et al., 2022). The outcome shows insights into first-year students' qualitative conceptions of individual variation and contextual narration which suggest that teachers should explore and consider the role of L2 self-concept and self-efficacy in L2 academic writing. The gap of this research compared to previous literature shows the possibility to conduct on the physics course's report for analysis purposes. The physics laboratory report serves as an intriguing context where theoretical knowledge meets practical application. It demonstrates how well students understand concepts through experimental observations. Additionally, this report acts as an initial step in assessing student capabilities, which is important for preparing them for future careers in STEM fields. This highlights the urgency of research in this area.

In these circumstances, this research aims to analyze the strategies that first-year students of engineering physics at UMN report writing in the laboratory class aspect. The main purpose is to identify the factors that affect the students' writing behavior by

comparing the report content with the assessment rubric. This eventually articulates the need for improvisation towards the strategy through the feedback concluded based on the analysis of the results. The method used will be based on a qualitative method that compares 10 reports based on different modules throughout the semester for writing behavior analysis which is limited to selected first-year students and participants in Universitas Multimedia Nusantara.

METHOD

This research approach focuses on a case study on the report writing strategies for Basic Physics 2 by first-year engineering physics students in Universitas Multimedia Nusantara. This design aims to analyze students' understanding of the course and how they elaborate their findings in the laboratory report. Thus, this study addresses the following research questions: How far do first-year engineering physics students understand Basic Physics Course through the experiment in the laboratory course:

1. How far do first-year engineering physics students understand the Basic Physics Course through the experiment in the laboratory course?
2. How far are first-year engineering physics students capable of fulfilling the report assessment criteria through their writing strategies?
3. What kind of improvement can be identified through the case study analysis?

Data Collection

4 first-year engineering physics students that attended Basic Physics 2 Laboratory course, which they have finished and passed Basic Physics 1, are asked to submit their reports which are collected from the first through the last week, a total of 10 reports per

individual. The reports are then graded based on the marking rubric provided by the lecturer and laboratory assistants. The analysis will be based on the report content and grading process which will identify possible improvisation as feedback. The necessity of this analysis is to answer the previous course, Basic Physics 1 Laboratory course, on the improvement of following the guidelines. The guideline, in written form, consists of details including the report template, descriptions of each heading and subheadings and points that are mandatory in the contents. Aside from the written requirement, the laboratory assistant also informed students on several details and information that should be done during the class to help in making good report writing. Details on the marking rubric with the indicator starting from invalid, insufficient, sufficient, good, and excellent (with 0 to 4 score respectively) can be given to 3 parts which are pre-test (15 points), report writing (10 points for practical data and 15 points for data analysis), and laboratory experiments (15 points for tools and material utilization, 20 points for practical procedures, and 20 points for teamwork). In this case, the rubric given focus on the report writing rubric which will be further assessed according to each output of the topic discussed in every meeting.

Data Processing

The submitted reports were analyzed using qualitative content analysis to systematically describe the phenomenon of first-year engineering physics students writing characteristics and pointing out gaps for improvement. The non-linear analysis will go through 3 stages. The first stage is for the researcher, also acting as the laboratory lecturer assistant, to read each report independently to grasp the overview of first-year student understandings. The second

phase is to compare the content of the report with the rubrics given by the lecturers for each topic and the desired output of the laboratory practical process. The third stage is to conclude the findings and highlight gaps for improvement which will be given as feedback for implementation in the following second-year courses which are Fundamental of Electrical and Electronics Circuit as well as Laboratory of Engineering Physics 1. It is hoped that these discoveries can encourage students to compare their next work to the requirement and help them become more familiar with the structure and content of a formal report since self-evaluation has been a key strategy in self-regulation.

RESULTS AND DISCUSSIONS

This research sets out the current writing characteristics of first-year engineering physics students through the analysis of laboratory reports in Basic Physics 2 to identify students’ understanding, capability to fulfill the assessment criteria as well as recommendation for improvement. Before further explanation, the following Table 1 represents the main topic and desired outcome of each module to be achieved by the students upon writing the report.

Table 1. Basic Physics 2 Desired Outcome

Basic Physics 2 Laboratory Topic	Desired Outcome
Electronics Circuit Instrumentation Fundamental	<ul style="list-style-type: none"> • Use instrumentation tools such as a multimeter, protoboard, oscilloscope, and function generator • Explain the calibration mechanism of the oscilloscope and function generator
Voltage and Current Measurement	<ul style="list-style-type: none"> • Use amperemeter and voltmeter • Analyze current and voltage measurement concept
Capacitance	<ul style="list-style-type: none"> • Use capacitance measurement tool • Analyze the capacitance change factor in a capacitor

Basic Physics 2 Laboratory Topic	Desired Outcome
Ohm's Law	<ul style="list-style-type: none"> Analyze series and parallel circuit Construct a resistive circuit
Electrical Power	<ul style="list-style-type: none"> Explain the conversion of electricity to light and heat Measure electricity power through current and voltage
Electromagnet	<ul style="list-style-type: none"> Differentiate between magnetic fields of linear, circular and solenoid electrical conductor Use magnetic field laboratory equipment
Printed Circuit Board	<ul style="list-style-type: none"> Design Printed Circuit Board using EAGLE software
Electromagnetic Inductance	<ul style="list-style-type: none"> Analyze magnetic flux changes through a certain period Use electromagnetic inductance laboratory equipment
AC Circuit	<ul style="list-style-type: none"> Define phase change in AC circuit as well as construct RC and RL circuit
Eddy Current-Transformer	<ul style="list-style-type: none"> Identify the relation between eddy current and transformer Explain the factor of layering to the conducted metal and analyze the eddy current-transformer relation
Electronics Circuit Instrumentation Fundamental	<ul style="list-style-type: none"> Use instrumentation tools such as a multimeter, protoboard, oscilloscope, and function generator Explain the calibration mechanism of the oscilloscope and function generator
Voltage and Current Measurement	<ul style="list-style-type: none"> Use amperemeter and voltmeter Analyze current and voltage measurement concept
Capacitance	<ul style="list-style-type: none"> Use capacitance measurement tool Analyze the capacitance change factor in a capacitor
Ohm's Law	<ul style="list-style-type: none"> Analyze series and parallel circuit Construct a resistive circuit

Findings

Data are collected and analyzed from the answers of four selected individuals for all ten course modules. These individuals were chosen due to them being the only students who take the subject at that period which serves as the population to represent a range of learning approaches and engagement levels within the student cohort, allowing

observation on diverse responses to the course material. Their answers were then rigorously compared and interpreted using the assessment rubric provided by the lecturers. The Report Analysis Rubric category assesses both practical data interpretation along with teamwork contributions. This targeted approach enabled a clear evaluation against the desired learning outcomes for each module, providing insights into broader trends in student understanding and performance. Table 2 presents these compliance results for each module, with 'D' indicating performance on the Data Aspect and 'A' on the Analysis Aspect for each individual.

Table 2. Student Score Results for Module Number (M.N) 1-10

M.N	1		2		3		4		5	
Int.	D	A	D	A	D	A	D	A	D	A
W	3.1	3.4	3.4	3.4	3.4	3.4	3.4	3.2	3.5	3.6
C	3.4	3.4	3.2	2.8	3.4	3.4	3.4	3.4	3.6	3.7
A	3.4	3.2	3.2	3.4	3.4	3.6	3.4	3.4	3.4	3.5
T	3	2.8	3.2	3	3.3	3.3	3.3	3.3	3.4	3.2
M.N	6		7		8		9		10	
Int.	D	A	D	A	D	A	D	A	D	A
W	3.6	3.5	3.2	3.4	3.1	3.4	3.1	2.9	3.4	3.2
C	3.7	3.7	3.5	3.7	3.2	3.5	3.5	3.5	3.3	3
A	3.7	3.4	3.3	3.3	3.2	3.5	3.3	3	3.3	3.2
T	3.6	3.6	2.7	3.5	3.2	3.3	3.4	3.2	3.2	3

The score of each individual has a maximum of 4 points from 1 based on the indicator given in the rubric from insufficient, sufficient, good, and excellent. This part of the report content rubric contributes to 25% of the whole score that can be obtained by the students. Although the number is not large, it significantly affects the overall score that

students get since other factors of the rubric can be easily fulfilled such as quiz scores, practical scores, and teamwork scores, which the researcher found that all students have a score ranging from 3.8-4 for the mentioned aspects.

Referring back to the results, it can be seen that from modules 1-10, each individual presents fluctuated results in both data and analysis aspects with no improvement trend. The highest score is 3.7 for both aspects while the lowest stops at 2.8 for the analysis aspect. The results showing the inability to receive maximum scores indicated that the report written by the students has many gaps that can be improved. Students are expected to give not only the mandatory answers based on the requirement given in each module but also their creative and critical analysis of the experiment conducted which includes the fundamental theory linking and real-life application explanation. Aside from the analysis aspect, some additional information must also be included in the data aspect to fulfill the maximum score such as presenting tables, circuit diagrams, graphs as well as equations that are not presented in the module template although briefly discussed during the course. Unfortunately, this is rarely seen in the report submitted by the four individuals. Further breakdown of each individual can be given in the following description of their report writing characteristics in Table 3.

Table 3. Report Writing Characteristics

Initial	Data Representation	Analysis	Understanding
W	Lack of graphs, tables, diagrams, and documentation.	Focus on data reading	Moderate
C	Presents sufficient graphs, tables, diagram, and documentations	Linking to theories and equations and present data reading	Sufficient

Initial	Data Representation	Analysis	Understanding
A	Lack of graphs, tables, diagrams, and documentation.	Linking to theories and equations and present data reading	Sufficient but writing structure is unorganized
T	Presents sufficient graphs, tables, diagram, and documentations	Linking to theories and equation but less data reading	Sufficient understanding

Based on the findings of the writing characteristics of each student, it can be summarized that compliance with the desired outcome as well as the rubric have been sufficient with much room for improvement.

Discussions

The findings identified in the previous section have shown that the score of compliance ranges around 2.8 to 3.7 for the data and analysis aspect which contributes to the overall score of the report grade for each student. In this case study, several notes from the findings include the lack of theories/concepts/equations linking with the experiment data analysis as well as the absence of additional graphs, figures, or additional tables that can help with solidifying the answers given in the report. Also, specifically for student "A", supplementary teaching on how to format a neat and structured report is important to enhance the overall result. Even though the report score in both aspects is satisfactory, the research points out that these students show no indication of improving in understanding and writing context. Moreover, prior to Basic Physics 2, these students had already attended Basic Physics 1 with the same lecturer and assistant, grading rubric, study process, as well as writing format. Yet, the report submitted in the further course had shown no sign of development, especially in the writing format.

Several factors that the researcher observed during the period of assistance with

the first-year engineering physics students that may influence this issue are the tendency to procrastinate, being unfocused and passive during the lecture, tiredness, difficulty digesting the given theory/material, as well as being unconcerned to explore the topic further. These are highly related to the self-efficacy and self-concept aspect of the students which in this case is categorized as low. These align with the findings from a study by (Mendoza et al., 2022) that students reporting low self-concept seemed to stem from weaker self-efficacy. They require guidance and feedback for academic writing by providing specific and meaningful needs from the lecturer as suggested by (Mendoza et al., 2022) and (Selwyn & Renaud-Assemat, 2020).

Since as mentioned, the students in this case had already received similar experience in report writing from the previous lecture, it clearly highlights that mastery experience is not enough to boost their self-efficacy. Moreover, engineers are expected to be professional with technical aspects while also being proficient in their communication and writing skills, so it is inevitable and important to improve their self-efficacy through self-concept. Thus, there is a need to develop students' self-concept and self-efficacy since both directly affect their writing skills. In accordance, the recommendation given for students to be implemented can be given in the following stages of writing according to the researcher as follows:

- Preparation = Before the lecture, students should manage their time to learn the topic and module. This will help in giving a clearer picture during the lecture while also highlighting unknown information that can be asked to the lecturer or assistant.
- In-Class = Students should utilize the time to learn as much as possible. Being

focused and initiative are highly recommended.

- Pre-Writing = Students should prepare the writing document with key ideas according to the topic of the module. These are adjusted according to the flow of the lecture or from the requirement of the lecturer.
- Writing = Students should elaborate the written ideas while also presenting critical analysis through theory/concept statements support and creative representation through visualization methods such using graphs and diagrams. The format of the writing should also be clear, concise, structured, and consistent.
- Evaluation = Feedback given by the lecturer and assistant should be taken as an important note for further implementation to improve the writing performance. Students are highly encouraged to consult lecturers to point out specific needs which can become more meaningful and impactful for students to be motivated on improving their writing skills.

Since student's skills have been based on their mechanism to organize information, plan, motivation, etc (Butt et al., 2020), it is encouraged for them to address their time management, social life, and awareness of emotional states as suggested by (Mendoza et al., 2022). In detail, they should always spare their time to learn the topic before and after the class to maximize their performance in analysis while also avoiding procrastinating.

Considering the prioritizing factor, students should place doing tasks as important while avoiding unnecessary time spent socially. Moreover, learning to be aware of their emotional states helps in avoiding writing unorganized reports. Finally, lecturers

also needed to be exceptionally involved in their approaches to teaching and providing feedback by carefully planning their curriculum (Basitere et al., 2023). This is regarded as a necessary forerunner to purposeful participation in their academic learning especially in self-efficacy (Mendoza et al., 2022).

CONCLUSIONS

This study is conducted to analyze first-year engineering physics students of UMN on their report writing for the Basic Physics 2 Laboratory course. Within 10 modules, the four selected individuals show different approach in writing which is shown by the score they obtain based on the data and analysis grade rubric. The rubric scores fulfillment by students conveys how well the students present their data on physics experiments and show correlation with theoretical knowledge through report writing structures. Although it considered to be sufficient for understanding and fulfillment to the assessment criteria since the score has reached above 3, several notes for each individuals includes providing details data from tables, graphs, equations, and figures as well as concise analysis by not limited to data reading but broaden up with theory comparison. Moreover, the overall results of the students show no improvement which shows the need to improve their writing skills throughout the stages from preparation, writing key ideas, further elaboration, and self-assessment from the feedback as the answer to boost their self-efficacy and self-concept. The limitation of this study is based on the participant's number and variety. Future research can stress more in comparison with various majors of first-year engineering students for broader outcome of the writing performance upon implementing the

mentioned solution. Concurrently, research on the effect of providing different approaches to teaching such as using scaffold methods (a technique to deliver lessons in distinct segments and provide less and less support when students had master concepts) for self-regulation or rewarding method for motivation may be helpful for wider, yet detailed analysis. The scaffolding approach can provide structures learning and embedded guidance while also reducing the need for extensive submission. While the rewarding method can cultivate the necessary motivation and resilience for students to engage with the demand on writing. Nonetheless, it is hoped that these findings can help students' self-evaluation to improvise their next work in the case of structure and content familiarization.

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