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Analysis of student responses to the implementation of a basic physics practicum guide using PhET Interactive Simulations, viewed in terms of learning outcome representations

Wahyu Dwi Puspitasari[a*], Filda Febrinita[b], Dewi Amiroh[c], Syifa Mareta[a]

[a] *System Computer Study Program, Faculty of Engineering and Informatics, Balitar Islamic University, Blitar, Indonesia, 66137*
[b] *Informatics Engineering Study Program, Faculty of Engineering and Informatics, Balitar Islamic University, Blitar, Indonesia, 66137*
[c] *Physics Education study program, Faculty of Teacher Training and Education, Khairun University, Ternate, Indonesia, 97735*

[*]*Corresponding author: pushpitasari23@gmail.com*

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ABSTRACT. Field testing of the developed basic physics practicum guide was necessary to gather information regarding its content, layout, and utility. Accordingly, the study described student responses to the guide during implementation in practicum sessions, specifically by examining students' learning outcome. The study used a descriptive research approach with purposive sampling, resulting in a sample of 12 students. The research stages included: (1) problem identification and formulation; (2) literature review; (3) selection of research subjects and samples; (4) development of research instruments; (5) data collection; (6) data analysis; and (7) drawing conclusions. The study categorized student learning representations as low, medium, or high based on the following thresholds: low (below 56.46), medium (56.46 to 81.66), and high (81.66 and above). Based on these criteria, the sample of 12 students comprised 4 in the low group, 5 in the medium group, and 3 in the high group. The results indicate that students with low level of learning outcome provided a positive response, with an average score of 75%. Students with medium and high learning outcome representations provided very positive responses, with average scores of 85.5% and 85.83%, respectively. This result indicated that most students responded very positively to the implementation of the basic physics practicum guide.

INTRODUCTION

A physics lab guide bridges the gap between conceptual theory and concrete laboratory evidence. Its primary benefit is providing structured instructions that enable students to conduct observations efficiently and independently [1]. Clear procedures help students obtain accurate data aligned with their objectives. Consequently, a lab guide is a crucial component for a successful, comprehensive physics learning process, particularly when utilizing virtual environments like PhET Interactive Simulations. Given the wide variety of basic physics activities available on the PhET platform, this study developed a dedicated lab guide for the Basic Physics course in the Computer Systems Study Program to maximize implementation and support students during laboratory sessions.

The developed basic Physics practicum guide has been adapted to the CPMK for the Basic Physics course in the Computer Systems Study Program. This guide contains 5 (five) practicum activities with different topics, namely vectors, straight motion, uniformly accelerated straight motion, parabolic motion, force, and impulse-momentum. Each practicum topic contains objectives, theoretical basis, tools and materials, practicum steps, practicum data results, and data analysis. The practicum guide has successfully passed expert validation and also small-scale trials. The results of the validation test with 3 (three) experts, namely material, media, and language experts, are that 2 experts (material and language) stated that it is very feasible, and 1 expert (media) stated that it is suitable for use. Subsequently, a small-scale trial involving five Computer Systems students who had completed the Basic Physics course demonstrated that the guide is highly suitable for instructional use [2]. The conducted research is currently limited to small-scale trials; thus, large-scale testing is required. Large-scale field testing can be implemented by integrating the developed lab guide into actual classroom lectures to collect student response data.

A response is defined as a behavioral reaction or answer elicited from an individual in response to a specific stimulus. Analyzing student responses is essential to evaluate the quality, clarity, and readability of the developed lab guide. Field trials involving many users are crucial for identifying product weaknesses before dissemination [3]. Theoretically, a well-structured lab guide effectively minimizes students' extraneous cognitive load during

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practical sessions. Confusing guides can burden students' working memory and hinder comprehension of the material being studied [4]. Therefore, collecting responses will provide a clear picture of the guide's ability to support students' practicum lectures. This aligns with previous research demonstrating that user response analysis in large-scale trials can confirm a product practicality level of up to 88% [5]. Empirical evidence from related studies demonstrates that clear information within lab guides significantly facilitates the execution of field-scale activities [6], [7].

User responses to a learning product directly correlate with and reflect students' subsequent academic performance. Student responses form a reciprocal cause-and-effect cycle. In educational psychology and learning theory, these two concepts do not stand alone but are linked by individual cognitive, affective, and conative processes. In Bloom's affective domain, responding (giving a response) is one level of value internalization. When students respond positively to lectures, it reflects that they have achieved mature affective learning outcomes. These affective learning outcomes (positive responses/attitudes) then become catalysts for improving cognitive learning outcomes (GPA or understanding of the material). This aligns with prior research revealing a significant correlation between students' learning responses and their conceptual understanding [8], [9]. Other research also states that students who respond positively to practicum guidelines experience improved learning outcomes [10].

Based on the aforementioned literature and empirical studies, the central problem of this research is the absence of field-scale trials to assess student responses to the newly developed lab guide. Therefore, further research is required to evaluate student responses to the lab guide during practical sessions and evaluate its impact on student learning outcomes. In this study, student responses refer to their perceptions regarding the content, appearance, and utility of the developed lab guide within Basic Physics courses. While prior research has explored this topic, this study introduces a unique perspective by comprehensively detailing student response outcomes. Before evaluating the student responses, we classified the students based on their learning outcomes. Students' final academic achievement is represented by their final grades in the Basic Physics course within the Computer Systems program. The purpose of this grouping is to determine whether students with different of learning outcomes respond differently to the laboratory manual. Subsequently, student responses will be analyzed across three ability levels: low, medium, and high.

RESEARCH METHOD

This study used a descriptive method to collect student responses to the implementation of a practicum guide. The research process followed seven systematic stages: problem identification and formulation, literature review, subject and sample determination, instrument development, data collection, data analysis, and conclusion drawing. In the first stage, the problem was identified and formulated by gathering preliminary data through direct observations of practicum activities. The second stage involved a literature review to collect relevant theories and past studies on field trials, student responses, and learning outcome representations. This step aimed to establish a theoretically sound solution to the formulated research problem. The third stage focused on determining the research subjects and samples. The research subjects were students from the Computer Systems study program by purposive sampling technique. The Sample selection's criteria are students from 2025 who are enrolled in the Basic Physics course and used the developed practicum guide. Finally, 12 students were selected for this study. [11]. Sample was categorized into three distinct groups based on their learning outcome representations: low, medium, and high. The determined using mean values and standard deviations, as detailed in Table 1.

Table 1. References for Grouping Student Learning Outcomes

Group	Limit Values
High	$X \geq M + (1{,}0 \times SD)$
Medium	$M - (1{,}0 \times SD) \leq X < M + (1{,}0 \times SD)$
Low	$X < M - (1{,}0 \times SD)$

(Source: [12])

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Information:
X : Learning outcomes
M : Mean value
SD : Standard deviations

The fourth stage is to compile a research instrument in the form of a student response questionnaire. This questionnaire was develope using a 4-point Likert scale: 1 (strongly disagree), 2 (disagree), 3 (agree), and 4 (strongly agree). The questionnaire developed consists of 10 statements, namely, (1) the practicum guide is presented in a coherent manner so that I am able to understand the objectives of the practicum activities; (2) the theory presented in the practicum guide helps me in understanding physics concepts; (3) the theory in the practicum guide helps me in solving problems presented in data analysis; (4) the practicum steps in the guide are clear so that they can be followed without the need for explanation from the lecturer; (5) the images in the guidebook are presented very clearly; (6) the data table of the practicum results is clear so that there is no confusion or error in recording the data; (7) the material used in the practicum is in accordance with the theory presented; (8) the rules for writing reports in the practicum guide are clear so that there are no difficulties in preparing the report; (9) The practical guide has an attractive layout of contents, cover and images with clear colors and not too many images so that the content is still highlighted; and (10) the basic physics practical using this practical guide makes me more enthusiastic in lectures. The research instrument tha used for data collection was adapted from a validated questionnaire in previous studies [13].

The fifth stage is data collection. Data collection was conducted after the research sample implemented the practical guidelines in lectures. The sixth stage is data analysis. The data obtained from the questionnaire distribution was then presented in a table and the percentage score (PS) of the student responses was calculated using the following equation (1) [14].

$$PS = \frac{S}{T} \times 100 \quad (1)$$

Information:
PS : Percentage Score
S : Score obtained
T : Total score (maximum)

The calculated percentage scores will be classified into four criteria based on Table 2.

Table 2. Student Response Categories

Percentage Score	Response Categories
$81\% - 100\%$	Very Positive
$61\% - 80\%$	Positive
$41\% - 60\%$	Moderate
$21\% - 40\%$	Negative
$0\% - 20\%$	Very Negatif

(Source: [13])

The seventh stage is concluding. Conclusions are drawn by referring to the results of categorizing student response percentage scores and reviewing the grouping of learning outcomes. This stage will conclusions about student responses to the implemented practicum guidelines, namely very positive, positive, moderate, negative,or very negative. A diagram of the research stages is shown in Figure 1 below.

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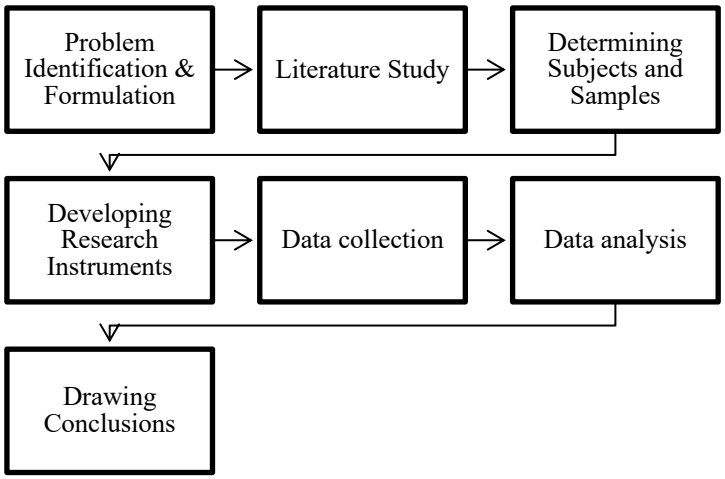

Figure 1. Research Stages of Student Response Analysis to the Implementation of Basic Physics Practical Guidelines with Phet Interactive Simulation Reviewed from the Representation of Learning Outcomes

RESULTS AND DISCUSSION

The analysis of student responses to the implementation of the practicum guide, by reviewing the representation of learning outcomes, followed the research stages in Figure 1. The first stage of this research obtained results related to the research problem, namely that a field trial had not yet been conducted on the developed practicum guide. Therefore, the purpose is to describe students' responses to the basic physics practicum guide with PhET Interactive Simulation in terms of the representation of learning outcomes. To achieve this objective, a literature review was conducted to synthesize relevant theories and previous findings able to resolve the research problem. The solution was to conduct research using a descriptive method, and the learning outcomes were represented as referred to in Table 1. Then, Table 2 was used to conclude the research. The next stage was determining the research subjects and samples. The research subjects were all students of the computer systems study program, and the research sample was 12 students from the class of 2025. Table 3 presents the learning outcomes of the research sample.

Table 3. Data on Basic Physics Learning Outcomes of Students in the Computer Systems Study Program

College Student	Learning Outcomes	
M1	68.81	Rerata = 69,06
M2	82.15	Strandar Deviasi = 12,60
M3	54.02	
M4	76.06	
M5	79.49	
M6	51.72	
M7	53.60	
M8	65.20	
M9	78.61	
M10	81.80	
M11	54.83	
M12	82.49	

Table 3 above shows the learning outcomes of the Basic Physics course after students used the lab guide. Based on this data, the average score was 69.06, and the standard deviation was 12.06. Furthermore, Table 4 details the classification boundaries for the learning outcomes based on the criteria in Table 1.

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Table 4. Limit Values for Grouping Student Learning Outcomes

Group	Limit Values
High	$X \geq 81{,}66$
Medium	$56{,}46 \leq X < 81{,}66$
Low	$X < 56{,}46$

Based on the limit values for grouping learning outcomes in Table 4 above, Table 5 represents the representation of Basic Physics learning outcomes for Computer Systems Study Program students.

Table 5. Representation of Basic Physics Learning Outcomes

College Student	Learning Outcomes	Group
M3	54.02	Low
M6	51.72	Low
M7	53.60	Low
M11	54.83	Low
M1	68.81	Medium
M4	76.06	Medium
M5	79.49	Medium
M8	65.20	Medium
M9	78.61	Medium
M2	82.15	High
M10	81.80	High
M12	82.49	High

Table 5 shows that three students are in the high group, five are in the medium group, and four are in the low group. The next stage involves preparing the research instrument. The research instrument is a student response questionnaire. The questionnaire follows the descriptions in the research method section and is administered via Google Forms. Next, the student response data collection stage was carried out. The results of the student questionnaire are shown in Table 6 below.

Table 6. Student Response Results to the Implementation of the Practical Guidelines

Respondents	Statement									
	1	2	3	4	5	6	7	8	9	10
M1	3	4	4	2	3	4	3	4	4	4
M2	4	4	3	3	4	3	4	4	4	4
M3	3	3	2	2	3	3	4	3	3	2
M4	4	4	4	3	4	3	3	4	3	3
M5	4	3	4	3	3	3	4	3	3	3
M6	3	3	3	3	3	3	3	3	3	3
M7	4	4	3	3	3	3	3	3	3	3
M8	3	3	4	3	4	3	3	3	3	3
M9	4	4	3	4	3	4	4	3	3	4
M10	4	3	3	3	4	4	4	3	4	4
M11	3	3	3	3	3	3	3	3	3	3
M12	3	3	3	3	3	3	3	3	3	3

The next stage after data collection is data analysis. The first step in data analysis is grouping student responses according to the representation of learning outcomes. Upon completing the grouping process, Equation

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(1) is applied to compute the obtained, total, and percentage scores for each group, with the comprehensive results summarized in Table 7 below.

Table 7. Results of Student Responses to the Implementation of Practical Guidelines in Accordance with Learning Outcome Representations

Group	Respondents	Statement									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Low	M3	3	3	2	2	3	3	4	3	3	2
Low	M6	3	3	3	3	3	3	3	3	3	3
Low	M7	4	4	3	3	3	3	3	3	3	3
Low	M11	3	3	3	3	3	3	3	3	3	3
S		13	13	11	11	12	12	13	12	12	11
T		16	16	16	16	16	16	16	16	16	16
PS (%)		81,25	81,25	68,75	68,75	75	75	81,25	75	75	68,75
Average of PS (%)		75,00									
Medium	M1	3	4	4	2	3	4	3	4	4	4
Medium	M4	4	4	4	3	4	3	3	4	3	3
Medium	M5	4	3	4	3	3	3	4	3	3	3
Medium	M8	3	3	4	3	4	3	3	3	3	3
Medium	M9	4	4	3	4	3	4	4	3	3	4
S		18	18	19	15	17	17	17	17	16	17
T		20	20	20	20	20	20	20	20	20	20
PS (%)		90	90	95	75	85	85	85	85	80	85
Average of PS (%)		85,50									
High	M2	4	4	3	3	4	3	4	4	4	4
High	M10	4	3	3	3	4	4	4	3	4	4
High	M12	3	3	3	3	3	3	3	3	3	3
S		11	10	9	9	11	10	11	10	11	11
T		12	12	12	12	12	12	12	12	12	12
PS (%)		91,67	83,33	75	75	91,67	83,33	91,67	83,33	91,67	91,67
Average of PS (%)		85,83									

Table 7 shows differences in the percentage values of student responses in the low, medium, and high learning outcome groups. The low group had an average percentage value of 75%, meaning that students with low learning outcomes gave a positive response to the implementation of the practicum guide. Furthermore, students in the medium group obtained an average percentage value of 85.50%, meaning that students gave a very positive response. Finally, the high group obtained an average percentage value of 85.83%, and the category is students with a very positive response to the practicum guide. Based on Table 7, the difference in responses between the medium group (85.50%) and the high group (85.83%) is only 0.33 percent. So, indicating that both groups show relatively similar responses. Although the low group gave a positive response, the value obtained was not the highest. This was caused by some respondents who still gave a score of 2 on 3 questionnaire statements. The statements that received a score of 2 in the low group were statement (3) the theory in the practicum guide helped me in solving the problems presented in the data analysis, statement (4) the practicum steps in the guide were clear so they could be followed without needing an explanation from the lecturer, and statement (10) basic physics practicums using this practicum guide made me more enthusiastic in lectures. This indicates a need for several revisions to the practicum guide. The revisions clarify the underlying theory and experimental procedures and add challenging laboratory activities to increase student enthusiasm. These results are in accordance with previous research, which states that student responses are related to learning outcomes [8], [9], [15], [16].

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The responses in the medium group are very positive. The average score is 85,5%. However, there was one statement in the questionnaire that received a score of 2, namely statement number 4: the practical steps in the guide are clear so that they can be followed without needing explanations from the lecturer. Based on these results, the college students were interviewed, and the results showed that respondents still needed explanations through other learning media for complex material, so understanding of physics concepts could be better. These results were also supported by several previous studies of media in learning to improve understanding of physics concepts. Previous studies stated that interactive learning media (animation, augmented reality, flipbooks, and virtual laboratories) can improve understanding of physics concepts [17], [18], [19], [20], [21].

This analytical study of student responses to the implementation of the basic physics practicum guide has been conducted and analyzed as planned. The results align with previous research and demonstrate the novelty outlined in the introduction. More specifically, this study's novelty lies in categorizing learning outcomes into three groups: low, medium, and high. This representation is then used to analyze student responses. However, this study still has weaknesses, namely the limited number of research subjects and the narrow research object. This weakness in the research subjects is due to the small number of students in the Computer Systems Study Program. Another weakness is the limited research time, which focused only on responses. Therefore, several further research steps can be taken based on the results of this study. For example, further research can be conducted in other study programs with a large number of students using quantitative methods. In addition, further research can be conducted by implementing a learning model. Future research could utilize this guide as an instructional tool to assess students' science process skills.

CONCLUSION

The research analyzing students' responses to the implementation of the PhET Interactive Simulation-based basic physics practicum guide has been successfully conducted. The results indicate that students in all groups achieved an average percentage above 70%. In detail, the following are the results of the average percentage of student response scores: (1) the student response scores included in the low learning outcome representation group is 75%, meaning they have a positive response; (2) the student response scores included in the medium learning outcome representation group is 85.50%, meaning they have a very positive response; and (3) the student response scores included in the high learning outcome representation group is 85.83%, meaning they have a very positive response. So, the results show that most students gave a very positive response to the PhET Interactive Simulation-based basic physics practicum guide in Basic Physics lectures. These findings indicate that the practicum guide received positive responses across all learning outcome groups and can be used to support Basic Physics practicum activities

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