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Correlating Practicum Performance and Student Perceptions in Virtual Basic Physics III: A Mixed-Methods Study

Charlos Falentino[1]*, Anggara Duta Medika[2], Grecellia Mei Magdalena Dakhi[1], Alphero Tanlianto[3]

[1*]Physics Education Study Program, Mulawarman University, Samarinda, Indonesia
[2]Mantappu Academy, Jakarta, Indonesia
[3]Department of Civil and Environmental Engineering, Nanyang Technological University, Singapore, Singapore
[*]Email: charlosfalentino@gmail.com

Abstract

This study examines the perspectives and experiences of Physics education students regarding the virtual implementation of Basic Physics III practicum. Using a mixed-methods approach, data were collected from 30 students at Mulawarman University through purposive sampling. The analysis was conducted using Spearman's rho correlation test to measure the correlation of basic physics practicum grades I and II to III, Likert scale analysis to measure readiness and perspective, metaphor analysis, and free response answers to analyze feelings and experiences. The results showed a moderate correlation between the final grades of Basic Physics practicum I and III, but there was no significant correlation between grades II and III. The Likert scale and metaphor analysis showed that students' experience was like a rollercoaster ride, where they felt happy when they understood, but confused when they did not understand. This study also found that learning styles (auditory, visual, kinesthetic) did not have a significant influence on the final grade of Basic Physics III practicum. Thus, this study supports the need for improvement and provision of basic physics practicum III tools, to be able to maximize student understanding in learning.

Keywords: Basic Physics III; Learning Style; Metaphor; Perspective; Virtual Practicum

Abstrak

Penelitian ini mengkaji perspektif dan pengalaman mahasiswa pendidikan Fisika mengenai pelaksanaan praktikum Fisika Dasar III secara virtual. Dengan menggunakan pendekatan metode campuran, data dikumpulkan dari 30 mahasiswa di Universitas Mulawarman melalui purposive sampling. Analisis dilakukan dengan menggunakan uji korelasi Spearman's rho untuk mengukur korelasi nilai praktikum fisika dasar I dan II ke III, analisis skala Likert untuk mengukur kesiapan dan perspektif, analisis metafora dan jawaban respon bebas untuk menganalisis perasaan dan pengalaman.Hasil penelitian menunjukkan adanya korelasi sedang antara nilai akhir praktikum Fisika Dasar I dan III, namun tidak ada korelasi signifikan antara nilai II dan III. Dari analisis skala Likert dan metafora menunjukkan bahwa pengalaman mahasiswa seperti naik rollercoaster, dimana mereka merasa senang saat mengerti namun bingung saat tidak memahaminya. Penelitian ini juga menemukan bahwa gaya belajar (auditori, visual, kinestetik), tidak memiliki pengaruh yang signifikan terhadap nilai akhir praktikum Fisika Dasar III. Dengan demikian, penelitian ini mendukung perlunya perbaikan dan penyediaan alat praktikum fisika dasar III, untuk dapat memaksimalkan pemahaman mahasiswa dalam belajar.

Kata kunci: *Fisika Dasar III; Gaya Belajar; Metafora; Perspektif; Praktikum Virtual*

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INTRODUCTION

One of the important components in education is students, students with character are students who have national insight, who usually have high social sensitivity to the problems faced by the nation. Not only sensitive, but after knowing the existing problems, he will usually make efforts to be able to fix them (Sihombing, 2020). Students are trained to improve problem-solving skills in almost every subject. One of the subjects that strongly emphasizes problem-solving is Physics (Harefa et al., 2020).

In learning physics, students are expected to not only master the concepts of physics in theory but also be able to use the scientific method to prove the concepts of physics obtained from the theory (Fauzi et al., 2013). It is not uncommon for physics to be considered difficult by students and teachers, so the teaching methods used must be considered so that the material is more easily accepted by students (Aisyah et al., 2024). Studying physics is very important, considering that physics is closely related to everyday life and natural phenomena, as well as a provision for learning basic technological knowledge (Anggeraeni et al., 2021; Eka et al., 2016). However, not all physics materials can be accepted by students, especially if the concepts are abstract and difficult to imagine in everyday such as Modern Physics (Hartono, 2011).

One of the important efforts to improve learning quality is to utilize laboratory advice as a support for science learning (Ilhamdi et al., 2020). A laboratory is a facility used to learn concepts through experiments, scientific research, so it is an important facility in supporting learning in schools (Falentino, Ikhsan Bachrul Alam, et al., 2024; Naimnule & Halek, 2022). In accordance with the Big Indonesian Dictionary (BID), practicum is defined as an activity that aims the aim students can test and carry out to gain direct experience related to the theory obtained in learning. One of the subjects that is always included in practicum activities is Physics (Sari, 2021). Laboratory practice is one way to achieve this goal. Nowadays, almost all the basics of physics taught to students are based on experiments, which require measurements that always contain uncertainty. In every laboratory activity, students make measurements and must analyze their data to draw a conclusion (A. Fauzi et al., 2013) The implementation of the practicum takes longer to explain the practicum procedure to students, so many students think that carrying out the practicum is very difficult (Sari, 2021). Previous research specifically found that there was an effect of physics learning using practicum methods on student motivation and learning outcomes (Ramadhani et al., 2022). The smooth running of laboratory practicum is supported by complete laboratory facilities and infrastructure, laboratory management, and good service. Service is the result generated by activities at the meeting point between the laboratory and users (students and lecturers) and by various internal laboratory activities (Ilhamdi et al., 2020).

In some study programs in Indonesia, Basic Physics Practicum can be divided into 3 levels: Basic Physics Practicum I, Basic Physics Practicum II, and Basic Physics Practicum III. Basic Physics Practicum I contains material that usually consists of coverage such as Kinematics, Dynamics, Effort and Energy, Fluids, to Heat. Basic Physics Practicum II contains materials such as Optics, Vibration and Waves, Electricity, and Magnetism. Basic Physics III Practicum contains materials such as Modern Physics, Relativity, Light Wave Dualism, Photoelectric Effect, Compton Effect, and other materials such as at the molecular and atomic levels. Generally, there are still many universities that do not have tools that support Basic Physics Practicum III, so some use virtual simulations such as PhET and Amrita as a website to carry out virtual practicum. Previous research shows that the performance of student reasoning skills in lectures using virtual simulations of PhET integrated with the LMS platform has increased (Verawati et al., 2022). Other research has also developed a virtual practicum module using Amrita for the topic of deviation and refractive index of prisms (Gare et al., 2022). Other researchers have found that the Amrita lab guide for the simple pendulum has successfully improved students' physics skills (Mukuan et al., 2024). Therefore, virtual laboratory technology is believed to be able to make the learning experience in the classroom more interesting and make students learn complex learning concepts more easily. (Warman et al., 2023).

When carrying out a practicum, one of the factors that needs to be considered is the student's learning style. Learning styles themselves are divided into 3, namely visual, auditory, and kinesthetic learning styles. Visual Learners are those who rely on non-verbal cues and focus on visual images, such as often taking notes and preferring to sit in front of a desk. Auditory learners find and interpret information by listening and prefer reading aloud. Meanwhile, kinesthetic learners prefer interaction with the physical world and an active and hands-on approach (Azizah et al., 2023). This learning style must be owned by every learner, some have a dominant one, or even some are dominant in two learning styles. Practical learning strongly uses kinesthetic learning styles as a supporting tool for the psychomotor aspects of students (Kyandaru, 2024).

But unfortunately, there has been no research that deeply analyzes how physics education students feel and their perspective on the Basic Physics III practicum conducted virtually, and its relationship with student learning styles. Therefore, this research is here to find out how the Correlation of Physics Education Students' Final Grades in Basic Physics Practicum Courses I and II to Basic Physics Practicum III is virtually. The second purpose of this research is to find out how the preparation and metaphors used by Physics Education Students in the Basic Physics Practicum Course III, which is carried out virtually. The third is to find out how the experience and feelings of Physics Education Students are when taking the Practicum Course in Basic Physics III virtually. And the fourth is to find out how the effect of learning style on the results of the Basic Physics III practicum. Through this research, it is hoped that it can provide information to educators to be able to maximize the learning of Basic Physics III practicum better, to maximize student understanding. This is important considering that it is a pre-service teacher who will become a professional teacher and teach at school. So, providing learning that can maximize teachers' understanding of basic physics practicum III is important, to be able to pass on their knowledge to their students later. It is also important to foster students' interest in science, considering that understanding is an important prerequisite for students to be interested in physics.

METHODS

Design

This study used a mixed-methods, concurrent (quantitative and qualitative measurements were taken at the same time) approach. Both quantitative and qualitative data were collected through a Google form distributed to participants.

Samples

The sample in this research used purposive sampling, namely, students who have taken and completed basic physics practicum III or Modern Physics Practicum courses. 30 fifth-semester Physics Education students from Mulawarman University were sampled in this research.

Instruments

Quantitative research was carried out using statistical analysis to find the correlation of students' course values, then continued with Likert scale analysis to find out students' perspectives on basic physics practicum III courses. The Likert scale used consists of 5-level items, ranging from 1 (Strongly Disagree), 2 (Disagree), 3 (Neither Agree nor Disagree), 4 (Agree), and 5 (Strongly Agree). To calculate the Likert scale percentage score, use Equation (1), where n_1, $n_{2,}$ …, n_5 is the number of students who choose the item level (Falentino, Mei Magdalena Dakhi, et al., 2024). For the interpretation of each score, see Table 1 (Falentino, et al., 2024; Putri & Suryati, 2016).

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$$\mathrm{Score} = \left(\frac{(\mathrm{n_1\ x\ 1}) + (\mathrm{n_2\ x\ 2}) + \cdots + \ (\mathrm{n_5\ x\ 5})}{(n_1 + n_2 + \cdots + n_5)\ x\ 5}\right) \mathrm{x100} \tag{1}$$

Table 1. Score Interpretation

Score	Category
0 ≤ score < 20	Very low
20 ≤ score < 40	Low
40 ≤ score < 60	Moderate
60 ≤ score < 80	High
80 ≤ score ≤ 100	Very high

Qualitative research was conducted using metaphor analysis, using an adaptation of instruments from previous research (Baş & Şentürk, 2020). Students were asked to provide metaphors for basic physics practicum III courses, along with the reasons. In addition, students were also given free-response questions regarding the experiences felt and the obstacles encountered when participating in the Basic Physics III practicum.

Analysis

To determine the correlation between the acquisition of the final grade of Basic Physics I, Basic Physics II, and Basic Physics III practicum, the Pearson correlation coefficient or Spearman's rho correlation can be used. The correlation between the level of student involvement in the basic physics III practicum and the final grade can also be measured using these two tests. Pearson correlation is used to measure the linear relationship between two continuous variables, but it must fulfill assumptions such as: both variables must be normally distributed, the relationship between the two variables is linear, the data is in the form of intervals or ratios, and there are no outliers (Stigler, 1989). On the other hand, Spearman's rho correlation is used to measure the monotonic relationship between two variables. Monotonic means that the relationship between the two variables must be unidirectional, i.e., consistently increasing or consistently decreasing. Spearman's rho correlation has several assumptions, such as that the relationship between the two variables must be monotonic and that the data must be at least ordinal. (Spearman, 1904). The absence of normality assumptions makes Spearman's rho correlation an alternative tool to Pearson's correlation.

Finally, it will also be tested whether there is a significant difference between the final scores of the Basic Physics III practicum in terms of student learning styles. Students are asked to take a learning style test on the website and indicate their learning style obtained on the questionnaire. In this case, the Kruskal-Wallis test will be used. The Kruskal-Wallis H test assesses whether the median ranking of basic physics practicum III scores is significantly different among the three learning style groups. This test is conducted by ranking all scores collectively and comparing the sum of the rankings between the groups. If the Kruskal-Wallis test shows a statistically significant difference ($p<0.05$), this indicates that at least one learning style group has different performance in the basic physics practicum III. In such cases, post-hoc pairwise comparisons, such as the Dunn-Bonferroni test, will be performed to identify the specific groups that differ. This method provides a reliable approach to examine the relationship between learning styles and the final grade of basic physics practicum III while accounting for the distributional nature of the data. However, it may still have limitations in validity, which is because the number of participants is still too small, so the sample for each learning style is also very small.

RESULTS

Correlation between the final grades of physics education students in Basic Physics Practicum I and II courses with their performance in the virtual Basic Physics Practicum III course

Through the questionnaire, the final score of the Basic Physics Practicum I, II, and III courses was obtained. The scores were then averaged and made into a graph (Figure 1). To determine the correlation between the final score of Basic Physics I practicum and Basic Physics III practicum, Pearson's correlation coefficient or Spearman's rank correlation can be used. To determine the type of correlation measurement, first the normality of the two datasets will be tested using the Kolmogorov-Smirnov test. The results can be seen in Table 2 and Figure 2.

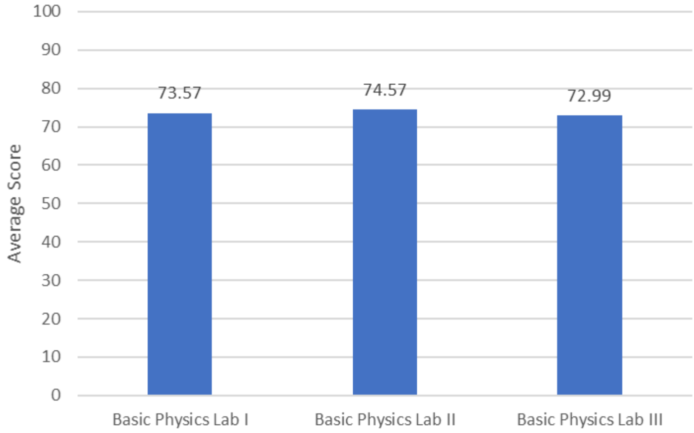

Figure 1. Average score of the results of Basic Physics Practicum I, II, and III

Table 2. Normality test of the final grade data of Basic Physics I practicum and Basic Physics III practicum with Kolmogorov-Smirnov test

Final Practicum Grade	p-value
Basic Physics I	0,112
Basic Physics III	0,000

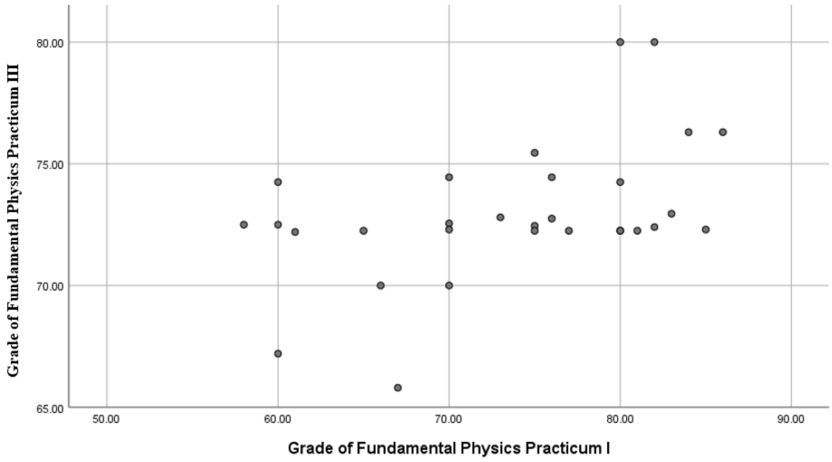

Figure 2. Scatter correlation graph of basic physics practicum I vs III

Since the data of the final score of Basic Physics III practicum is not normal, the correlation measurement will use Spearman's rank correlation. As a result, a correlation coefficient of 0.404 was obtained with a p-value of 0.027, which qualitatively indicates a moderate level of correlation. This indicates that there is a tendency for students who perform well in Basic Physics I practicum to also perform well in Basic Physics III practicum. This can be seen for several reasons. The first possibility is that the concepts needed in Basic Physics I Practicum are related to the concepts used in Basic Physics III Practicum.

To determine the correlation between the final score of Basic Physics II practicum and Basic Physics III practicum, Pearson's correlation coefficient or Spearman's rank correlation can be used. To determine the type of correlation measurement, first, the normality of the two datasets will be tested using the Kolmogorov-Smirnov test. The results can be seen in Table 3 and Figure 3.

Table 3. Normality test of the final score data of Basic Physics II practicum and Basic Physics III practicum with Kolmogorov-Smirnov test.

Final Practicum Grade	p-value
Basic Physics II	0,200
Basic Physics III	0,000

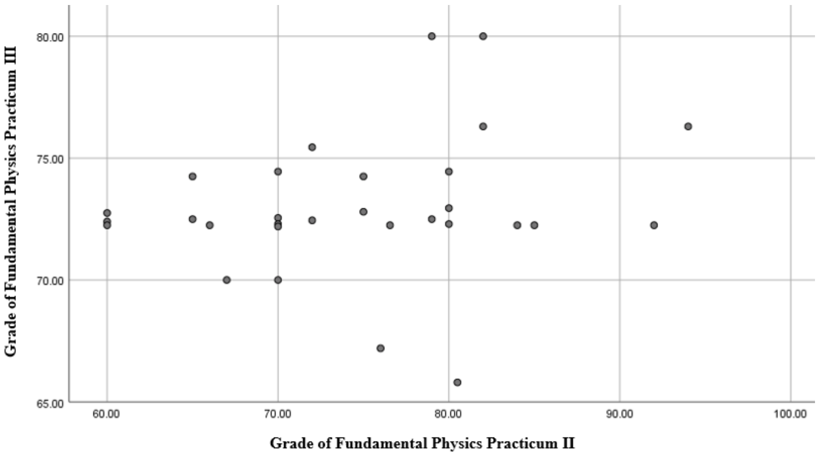

Figure 3. Scatter Correlation Graph of basic physics practicum II vs III

Since the data of the final score of Basic Physics III practicum is not normal, the correlation measurement will use Spearman's rank correlation. As a result, a correlation coefficient of 0.157 was obtained with a p-value of 0.407, which qualitatively indicates a very weak correlation level. On the other hand, the measured correlation coefficient is not statistically significant. Therefore, in this case, there is no evidence to suggest that predictive value for their performance of students in the Basic Physics III practicum.

Students' perceptions and preparation for the virtual Basic Physics III practicum

Through questionnaires, data were collected to explore student perceptions and preparation for the virtual Basic Physics III practicum. The results were measured using a Likert scale to assess various aspects of student engagement. A summary of these findings is presented in Table 4.

Table 4. Likert scale questionnaire results and interpretation

No	Questions	Percentage Score	Interpretation
1	I take the time to learn the material about Basic Physics III (Modern Physics) practicum before the course is taught.	63%	High
2	I prepare questions before entering the basic physics practicum III (Modern Physics) course.	51%	Moderate
3	Learning Basic Physics Practicum III (Modern Physics) material is exciting (Fun)	66%	High
4	Learning Basic Physics Practicum III (Modern Physics) material often makes me sleepy.	62%	High
5	Notes on Basic Physics Practicum III (Modern Physics) material are not as complete as my notes in other physics courses.	61%	High
6	When asked about basic physics practicum III material, I can explain with confidence.	56%	Moderate

Based on the results obtained, it was found that the majority of students (63%) dedicated a considerable amount of time to studying the Basic Physics III practicum material before attending the course, indicating an initial awareness of its importance. However, only 51% of the students prepared questions beforehand, suggesting that while they reviewed the material, deeper reflection or critical engagement was still lacking. A total of 66% of the students felt that the practicum was interesting, yet, interestingly, many also admitted to often feeling sleepy during the sessions. This could be due to the challenging and abstract nature of the course, which on one hand sparks curiosity, but on the other hand, when students begin to feel confused or lost, it leads to mental fatigue and drowsiness. Furthermore, 61% of students reported that their notes on the Basic Physics III practicum were not as complete as those for other subjects, indicating difficulties in following and summarizing the course content effectively. The results also showed that students' confidence when asked to explain the practicum material remained relatively low (56%), highlighting the need for more interactive learning approaches and additional support to help students better understand the material, retain information, and improve their confidence in expressing what they have learned.

The results of the questionnaire also revealed a variety of metaphors provided by physics education students concerning the Basic Physics Practicum III, as shown in Table 5. These metaphors reflect the students' perceptions, feelings, and experiences during the practicum. Furthermore, the categorization of these metaphors, which provides deeper insights into the themes and meanings behind the students' responses, is presented in Table 6.

Table 5. Metaphor Regarding Basic Physics Practicum III

Methapors	Number
A Sea of Particles	1
Banged	1
Challenging	1
Computer	1
Dancing with the Laws of Nature	1
Dark	1
Dazed and confused	1
Exploring the labyrinth of the quantum world	1
Exploring the unseen world with a new lens of knowledge	1
Flow like water	1
Labor	1
Labyrinth	1
Learn to swim without water	1
Like trying to explain colors to a blind man	1
Motorcycle	1
Oil	1
Ocean	1
Opening a door to an unseen world	1
Opening the door to the invisible world	1
Opening the door to the hidden universe	1
Puzzle	1
Rain	1
Rollercoaster	1
Ruler	1
Storm	1
Struck by lightning	1
Swimming in the middle of a storm	1
Waves	3

Table 6. Categories of Metaphor

Category	Metaphors
Difficult and Dizzying (11)	Computer (1), Dark (1), Daze and Confused (1), Exploring the labyrinth of the quantum world (1), Labor (1), Labyrinth (1), Learn to swim without water (1), Like trying to explain colors to a blind man (1), Rain (1), Storm (1) Swimming in the middle of a storm (1),
Fun and Challenging (4)	Challenging (1), Motorcycle (1), Puzzle (1)
Makes You Go Up and Down (3)	Rollercoaster (1), Waves (3)
Opens New Insights (5)	Exploring the unseen world with a new lens of knowledge (1), Ocean (1), Opening a door to an unseen world (1), Opening the door to the invisible world (1), Opening the door to the hidden universe (1)
Characteristic of Modern Physics (4)	A Sea of Particles (1), Banged (1), Oil (1), Struck by lightning (1)
Out of Other Categories (3)	Dancing with the Laws of Nature (1), Flow like Water (1), Ruler (1)

Experiences and feelings of physics education students during the virtual Basic Physics III practicum

Many of the students felt an exciting experience while participating in the Basic Physics III Practicum. This illustrates that this material is interesting and arouses student curiosity. But on the other hand, when students also feel moments where they feel they do not understand or are confused. Some students also expressed a feeling of satisfaction when they managed to understand the concept of Basic Physics III practicum.

"It's fun to learn new things, but sometimes there are some things that make you confused because the practicum is done online."

"Fun but quite difficult because it discusses abstract things."

"It's fun and challenging when learning, but sometimes it's also confusing because the practicum is online."

"At first, the concepts of modern physics seemed abstract and difficult to understand, but through experiments and simulations, I began to connect them with real evidence. It was a mixed feeling at the beginning, but satisfying when I managed to understand the complicated concepts. There was also satisfaction in seeing modern physics theories applied directly, as if opening the door to a deeper understanding".

"I feel curious and challenged in Basic Physics Practicum III because the concepts of modern physics are interesting, but I often feel overwhelmed by the complicated theory. Even so, success in understanding or obtaining the right experimental results gives a sense of satisfaction and pride."

"Experiences and feelings following the basic physics practicum III course, actually quite exciting because it uses a virtual lab, and there are already guidelines and descriptions of each button, so that practitioners are a little facilitated in conducting experiments. Practitioners are also accompanied by practicum assistants, so when confused about demonstrating virtual labs, we can directly ask the practicum assistants. What makes me feel like a rollercoaster is when taking experimental data, which we must do with accuracy. But when I have done other experiments, I feel happy, especially when I understand the calculation data."

Quite a few students also reported feeling stressed while studying Basic Physics Practicum III. This stress may stem from feelings of boredom and a lack of understanding of the practicum activities. Such challenges can hinder student engagement and overall learning outcomes.

"I really feel depressed and stressed."

"I feel stressed and quite depressed, feeling sad too, because I don't understand and understand why the practicum is virtual or the mechanism is like that. So working on it is only based on following the procedure, I feel bored and become lazy to work on it too, because I don't understand the flow of concepts and why the virtual lab mechanism is like that.

Many students find it difficult to understand the concepts of Basic Physics Practicum III because the concepts are abstract and difficult to understand. In addition, practicum conducted virtually is also still an obstacle for students to be able to fully understand Basic Physics Practicum III. There are also complaints about obstacles due to poor internet connections.

"I find it difficult because the abstract concepts of modern physics are difficult to understand intuitively."

"Yes. Because the material is very complex and different from the classical physics material that we often learned during our school days."

"It is very difficult to understand, more often than not, we are asked to follow procedures, but we don't really understand why it has to be done. So, when it has been implemented and the data is obtained, it is unclear what to apply and interpret.

"Because the experiments in Basic Physics III are not carried out using props, and only virtual labs, which makes it difficult for practitioners to carry out experiments."

"There is, the difficulty is that in the practicum of basic physics III, I was unable to open the PhET practicum simulation site because at that time it was very difficult with a limited

Comparison of final grades in Basic Physics Practicum III based on students' learning styles

Physics education students were asked to do a learning style test from a website, then the results are shown in Table 7. To determine whether there is a significant difference between the final scores of Basic Physics III practicum in terms of student learning styles, the Kruskal-Wallis test will be used. As a result, the Kruskal-Wallis H value is 1.404 with a p-value of 0.496. There is no statistically significant difference in the final score of Basic Physics III practicum among the three learning styles.

Table 7. Learning styles and the number of students

Learning Styles	Number of Students
Kinesthetics	9
Auditorium	1
Visual	5
Auditorium, Kinesthetics	2
Visual Kinesthetics	10
Visual Auditorium	2
Visual, Auditorium, Kinesthetics	1

DISCUSSION

Correlation between the final grades of physics education students in Basic Physics Practicum I and II courses with their performance in the virtual Basic Physics Practicum III course

Given that in the concept of modern physics, very closely related to the concept of classical physics, such as Galileo Transformation and the law of conservation of energy. So that if students have a good understanding of the concept of classical physics and its practicum, then they will have no difficulty if they study the practicum of modern physics or basic physics III. Vice versa, if students do not understand well, then they will have difficulty in learning basic physics III practicum, because their understanding of classical physics concepts is still weak. Educators note that classical physics knowledge can "serve as a bridge to quantum phenomena" (Reyes-Martín & Arroyo-Hernández, 2025). In other words, students who thoroughly understand classical principles (such as Galilean frames of reference or energy conservation) are better prepared to grasp the abstract principles of modern physics. For example, some researchers argue that placing a stronger emphasis on Galilean (classical) transformation in teaching helps students appreciate the profound differences introduced by Einstein's relativity (Alstein et al., 2020). Emphasizing classical reference frames and motion in the non-relativistic limit can thus smooth the transition to special relativity by reinforcing foundational concepts. Empirical studies have found that strong performance in classical physics correlates with better outcomes in modern physics courses. For instance, a recent education dissertation identified high school physics background and achievement as the most important predictors of conceptual understanding in college physics (Sachini & Hewagallage, 2019). Students who had taken rigorous physics courses (covering classical mechanics and electromagnetism) and performed well in them showed substantially better understanding of advanced topics. This suggests that students entering modern physics with a solid grasp of classical fundamentals tend to excel, whereas those lacking that foundation struggle. The second reason for this correlation could be that the courses are equally difficult but for different reasons of challenge.

First-Semester Transition Challenges: The first year of university is a well-known period of adjustment, and students often face a range of transitional challanges-academic, social, and personal. Studies in higher education find that "first-year students often experience a range of transitional challenges, including academic, social, financial, and emotional difficulties. (Cameron & Rideout, 2022). These challenges are not confined to the first few weeks; in fact, they can persist throughout the entire first year of study. (Cameron & Rideout, 2022). Incoming freshmen may not be fully prepared for the self-directed learning expected at university, and they are simultaneously adapting to new teaching styles, larger workloads, and higher expectations. In the context of Basic Physics Practicum I (usually taken in the first semester), this adjustment period can negatively impact performance. New physics students might struggle with unfamiliar lab report formats, college-level problem-solving, time management, and the independence required in laboratory work. It is during practicum I that they learn how to calibrate equipment, follow experimental procedures diligently, and write scientific reports – all skills that likely differ from their high school experiences. As a result, it's common to see somewhat lower scores in Practicum I as students are still finding their footing in the college environment.

Improvement with Adaptation in Practicum II: In basic adaptation in Practicum II (often in the second semester), many of those initial hurdles have been overcome. Research suggests that students begin to develop better self-directed learning skills over the course of the first year. They become more accustomed to the academic rigor and have adjusted their study habits. Peer support networks also form, which can help students navigate coursework. In practical terms, students entering practicum II are more "adapted to learning in a university environment". They likely have experience with the laboratory equipment and reporting requirements from practicum I, and they may feel more confident and efficient. This adaptation often translates into improved performance in Practicum II – instructors frequently observe higher lab grades or more competent experimental work in the second semester. Essentially, as students settle into the college system, their lab work quality and exam scores tend to rise compared to the first semester.

Challenges in Practicum III (modern physics): In Basic Physics Practicum III, which typically focuses on modern physics experiments, student performance can dip again relative to Practicum II. Two main factors contribute to this: the abstract nature of the content and the less direct way experiments are conducted. Modern physics experiments (e.g., on atomic spectra, radioactivity, quantum phenomena) often cannot be performed with simple hands-on setups due to safety or resource constraints; instead, students might engage with simulations, demonstrations, or analyze provided data. Educational researchers point out that *many modern physics topics "do not have easily available hands-on instructional aids"*. Because these experiments are less tangible – students aren't directly turning knobs or observing phenomena in real time as they did in mechanics or electricity labs – it can be harder for them to draw a connection between theory and observation. This abstractness demands higher conceptual reasoning. Moreover, modern physics introduces non-intuitive concepts (wave-particle duality, relativity, quantum uncertainty) that students find inherently challenging to grasp. As one study notes, *quantum-level phenomena cannot be directly observed or intuitively understood in classical terms* (Ubben & Bitzenbauer, 2023), making the learning curve steep. Consequently, even well-adapted students may see their scores drop in Practicum III compared to Practicum II, simply because the material complexity is greater. The combination of dealing with simulations or indirect experiments and confronting counter-intuitive concepts can reduce success rates. Indeed, classroom experiences and studies have reported that only the top students manage to excel consistently in modern physics labs, while others struggle with the leap in abstraction.

Students' perceptions and preparation for the virtual Basic Physics III practicum

The metaphors above can be categorized into several groups based on the reasons provided by the students, as shown in Table 6. These categories reflect different aspects of the students' perceptions and experiences. For a more detailed explanation of each category, please refer to the following section.

Difficult and Dizzying

The metaphors grouped into this category contain the difficulties felt by physics education students when taking basic physics practicum III. Some examples include students; *Labyrinth*, because "It is difficult and full of accuracy in taking data, for example in taking data in the Milikan Oil Droplet practicum, we must be careful in taking data where"; *Computer*, because "It is difficult to understand, difficult to imagine, difficult to understand". Some students explain the difficulty of virtual practicum because these students have a kinesthetic learning style or who understand more easily when using their learning tools directly; *Learn to swim without water*, "because maybe some people can understand how to swim just by reading, watching videos, or hearing explanations, but I must do it in the right place, with the right tools, to understand. Unfortunately, the practicum of basic physics III for me is very difficult, I do not understand the concept, even the preparation of the report I did by looking at references belonging to senior brothers". Some students express their difficulties because of the abstract nature of virtual practicum for students, making it difficult for them to imagine and become dizzy; *Daze and Confused* because "the material is abstract, it makes them confused and makes them dizzy thinking about it".

Fun and Challenging

Not a few students also feel an exciting experience when participating in the virtual practicum of basic physics III. Some students mention *Challenging* because "in doing this practicum we need to apply theory with practicum, then in practicum skills are needed that are not all taught in class, and practicum also involves problem solving so that this is quite sharpening thinking to solve problems and in practicum often asked for output in the form of reports in doing reports we are sometimes pursued by deadlines". There are also those who mention *puzzles*, because "at that time it was a virtual practicum and it was like having to figure it out yourself first before being told by the practicum assistant". There are also students who relate exciting experiences during practicum such as when carrying a motorcycle, *Motorcycle*, because "it's fun and interesting".

Makes You Go Up and Down

This category reflects students who had an up-and-down experience while taking the virtual basic physics III practicum. They felt excitement when they understood it, but felt difficulty and confusion when they did not understand it. Some students mentioned metaphors such as a *Rollercoaster.* "I describe the rollercoaster in the practicum of basic physics III because the experience of facing this course is full of emotional ups and downs. There were times when I felt understood and confident, but on the other hand, there were also moments when complicated concepts left me confused or overwhelmed. This feeling is like a rollercoaster ride that is full of surprises, sometimes thrilling, but also brings a sense of satisfaction every time I successfully pass the challenge". Some students also mentioned metaphors such as *Wave*, with the same reasons; "Like waves that never stop coming, making it fun because through the website and make you drown if you don't understand and get carried away if you understand how to practice"; "because in the practicum of basic physics III I was tossed around but still followed the current".

Opens New Insights

This category reflects students who feel that the virtual practicum of basic physics III has opened new insights for students. Some students mention the Ocean because "The further we explore this ocean (the deeper we study Modern Physics), the more unexpected and amazing things we find". Some associate it with "Opening a door to an unseen world" because "modern physics discusses concepts that are far from everyday experience, such as quantum mechanics, relativity, and particle theory. At this microscopic level, the laws of physics do not always follow the logic we are used to". There are also those who analogize it as "Exploring the unseen world with a new lens of knowledge" because "it is very relevant for Basic Physics Practicum III (Modern Physics) because in this practicum students explore concepts that they cannot see or experience directly. In modern physics, many concepts-such as quantum mechanics, relativity, or particle physics-do not have direct visual representations or do not match our everyday intuition."

Characteristic of Modern Physics

In this category, students use metaphors related to elements in modern physics concepts. For example, "A sea of particles" because "it discusses a lot about particles, subatomic particles that cannot be seen directly or invisibly". Some associate it with "banged", because basic physics III is all about the collision of new particles of light shear, the same relative value". There are also those who convey the uniqueness or memorable things that students feel when carrying out the Basic Physics III practicum by using metaphors related to the practicum, *Oil*," because it is most memorable where we are led to calculate the time of falling oil, it turns out that small things in physics all have to be thought about, they cannot be enjoyed".

Other Categories

In the other categories are student answers that are not directly related to the practicum of Basic Physics III and do not fit into several existing categories. Some of their metaphors, such as *Dancing with the Laws of Nature*, in this practicum, we are like dancing to the strains of natural law. Each step in the experiment is our attempt to align with the existing principles of physics. Through the rhythm of experimentation and data analysis, we learn to follow the patterns of the universe. Some answer it as a *ruler* because "my score does not go up and down, it remains 70 like a straight ruler". Some answered that they were more relaxed and not so bothered by the practicum, *flowing like water*, because "that's all they had to do".

Based on these results, students have good preparation, such as studying basic physics practicum III material before entering the room. However, the curiosity and activeness of students, for example, in asking questions, are still lacking. There is also a unique result, where the percentage of students who say Basic Physics III practicum is exciting and makes them sleepy is approximately the same. This is consistent with the metaphors given by students, where there are moments when they feel that Basic Physics III practicum is exciting, especially when they understand, but there are also moments when they do not understand the practicum, so they feel sleepy. Examples of metaphors used by students, such as Rollercoaster, which describes moments of ups and downs, sometimes Basic Physics III practicum can be exciting, sometimes confusing. (Madsgaard et al., 2022), In their integrative study of simulation-based learning found that simulation situations can be stressful experiences; students often experience high emotional variability during simulations, like riding a rollercoaster of emotions. They may feel anxiety and stress before and during the virtual practicum activity, followed by relief or excitement after completing the task. This is also in line with previous research, which says that teaching material that has a high level of abstraction, such as modern physics, can have an impact on low student reasoning and decreased interest and motivation to learn (Verawati et al., 2022). When interest and motivation to learn decrease, this can lead to sleepiness. Students' confidence in being able to re-explain Basic Physics III Practicum is also not very high. This can be caused by the complicated concept of Basic Physics III practicum, which makes students' understanding of concepts lower, so that the confidence of students is also low. This is following previous research, which suggests that the ability to understand students' mathematical concepts can be seen from the high and low confidence of students; the higher their confidence, the more confident they are to be able to solve these concept problems (Nurfajriyanti & Pradipta, 2021). This is also consistent with the metaphors given by students, where they see Basic Physics III practicum as something difficult, such as metaphors such as computers, mazes, because it is difficult to understand and complex. This sense of student confidence also affects creative thinking skills, as shown in previous studies, where students who have high self-confidence will have high creative thinking skills, as well as those with moderate self-confidence will have moderate creative thinking skills (Eviliasani et al., 2018).

Experiences and feelings of physics education students during the virtual Basic Physics III practicum

Based on the free response answers, it can be understood that the feelings and experiences of students when participating in the Basic Physics III practicum are exciting and challenging. This opens up to us that the practicum of Basic Physics III, which is abstract, can arouse students' curiosity. They also explained the confusion and stress they felt, especially when they did not understand the concept of Basic Physics Practicum III. This is in line with previous research, which revealed that academic stress felt by students is one of the factors caused by students' poor understanding of the course material (Fauzi et al., 2021; Fitriani et al., 2022). In addition, abstract material can reduce student interest and motivation to learn. Based on Acedillo & Saro (2023) study, it showed that low levels of interest and motivation to learn had an impact on students' active participation in class discussions. Other studies have also revealed that students' difficulties in quantum learning are a lack of mathematical abilities (Bouchée et al., 2022). This is also coupled with the preparation of reports after collecting data, if the task load is too much while understanding the material is little, it can lead students to stress (Al-Marwaziyyah & Chori, 2022). This clearly needs to be considered, as stated by previous research, which conveyed that abstract material can reduce student interest and motivation to learn (Verawati et al., 2022). This was further clarified when asked about the challenges felt by students, where they conveyed that abstract concepts and difficult to understand, as well as practicums that were carried out virtually, became their obstacles during the Basic Physics Practicum III. More clearly, some students pour out their hearts when they do not understand the theory of modern physics, but still struggle to follow the flow of the practicum. This is an evaluation material for policymakers and educators, highlighting the importance of equipping students, especially in difficult subjects such as modern physics, so that they can carry out practicum not only just doing experiments, but also can understand the concepts and essence of the science they learn.

Comparison of final grades in Basic Physics Practicum III based on students' learning styles

There is no statistically significant difference in the final score of Basic Physics III practicum among the three learning styles. This shows that learning style (either visual, auditory, or kinesthetic) has no significant impact on students' performance in Basic Physics III practicum. Students with different learning styles have the same performance in this practicum. This result is quite different in theory, considering that kinesthetic learning styles, where students learn best through physical activity and hands-on practice, may influence the level of difficulty experienced in virtual physics labs. The shift to online learning during the COVID-19 pandemic led to the loss of traditional kinesthetic experiences in lab activities, and this has been shown to negatively impact students' mastery of scientific skills. Legaspino et al., 2024, reported that the absence of a hands-on component in remote science practicums resulted in the inhibition of students' development of science process skills. Without the opportunity to “touch and manipulate” directly, students with kinesthetic preferences may find physics concepts more abstract and difficult to understand. However, it seems that these results are not as significant due to the limited number of students measured for each learning style. In addition, it could be because senior students at the university already have a lot of experience, so the differences in learning styles do not affect them as much. One of the students in the study even revealed that if they did not do the experiment themselves and only saw instructions, it would be difficult to absorb the lesson. This result is in line with previous research, which found that there was no significant interaction in blended learning on the learning outcomes of students on the algorithm and programming material (Nuryulianti et al., 2024). Where in the practicum of Basic Physics III, which is done virtually, stimulates both psychomotor, visual, and audio at an equal level, so there is no different influence on the three learning styles.

CONCLUSION

This study aimed to (1) determine the correlation between Physics Education students' final grades in Basic Physics Practicum Courses I and II and their performance in Basic Physics Practicum III conducted virtually; (2) examine how students prepared for the virtual Practicum III and the metaphors they used to describe their experience; (3) explore students' experiences and feelings during the virtual Practicum III; and (4) assess the influence of learning style on Practicum III outcomes. The findings indicate that students' scores in Practicum I and III are positively and strongly correlated, whereas the correlation between Practicum II and III scores is very weak, underscoring the critical role of foundational conceptual understanding from Practicum I. Although most students reported adequate preparation for the virtual practicum, they were generally less active in formulating questions. Their perceptions of the virtual format were mixed—enthusiasm when concepts were grasped versus stress when material proved challenging, metaphorically described as "roller coasters" or "puzzles." No significant differences in Practicum III performance were observed across visual, auditory, and kinesthetic learners, suggesting that the virtual format provides a balanced audio-visual-psychomotor experience. The implication of the results of this research in the world of education is the importance of intensive assistance by lecturers on abstract basic concepts of physics, especially in Basic Physics Practicum III. However, the study has several limitations. The sample was drawn from a single institution, and its relatively small size, especially for each learning-style subgroup, may have reduced the statistical power to detect differences by learning style. Future research should employ longitudinal designs to track students' learning trajectories, expand to multiple universities, and recruit a larger, more diverse cohort, particularly to robustly examine how different learning styles affect virtual practicum outcomes. Additionally, studies should investigate how the transition from high school to college influences student engagement and performance in virtual physics practicums.

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