IJIET, e-ISSN 2548-8430, p-ISSN 2548-8422, Vol. 7, No. 2, July 2023, pp. 319-332

International Journal of Indonesian Education and Teaching
http://e-journal.usd.ac.id/index.php/IJIET
Sanata Dharma University, Yogyakarta, Indonesia

UNDERGRADUATE ENGINEERING STUDENTS' ATTITUDE TOWARDS THE USE OF PHYPHOX IN PHYSICS EXPERIMENT

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https://doi.org/10.24071/ijiet.v7i2.6182
received 31 March; accepted 26 July 2023

Abstract
During the pandemic, the faculty of engineering at Trisakti University still used old apparatus and onsite learning in practical lectures, albeit with some COVID restrictions. Nowadays, when the pandemic is going out the faculty is trying to implement a new method in practical lectures using a smartphone-based application to enhance the effectiveness of physics experiments. This research aims to discover the students' attitudes toward the use of Phyphox in physics experiments and to examine the differences in the attitude between students with various backgrounds, such as gender, department, smartphone use, and prior experience. Two hundred self-developed questionnaires were delivered to seven departments in the faculty of engineering that have participated in this research. The findings indicated that: gender correlated to significant differences in some factors of attitude; smartphone use did not affect attitude; students with prior experience showed more positive attitude; and the major taken by students correlated with majority of factors of attitude towards the use of Phyphox in physics experiment. This research article presents a case study of the integration of the Phyphox application, that utilises the smartphones' integrated sensors in hands-on physics experiments, in an inquiry framework.

Keywords: attitude, Phyphox, smartphone-based application

Introduction
The quality of education can be enhanced by science and technology, which is one of the contributing factors. As a result, we are now well-acquainted with the internet and a range of digital devices, such as computers, laptops, tablets, smartphones, and other similar technologies. The Global Education Census discovered that Indonesian students frequently use technology in the classroom to a greater extent than many other countries, sometimes even outperforming more advanced nations. This statement is supported by data from Cambridge

Assessment International Education (2018) which stated that Indonesian students are the highest globally in their use of IT suites or computer rooms (40%). They are also the second-highest in the world for using desktop computers (54%), behind only the USA.

The usage of technology in the classroom has the potential to facilitate physics practical activities for students and make them more accessible and engaging. With the emergence of the COVID-19 (Coronavirus Virus Disease) outbreak learning technology became more vital than ever, especially when the Indonesian government issued a Work from Home (WFH) policy. People need learning technology to strengthen online learning (Wahyudi et al., 2022). One of the technologies that can be used to facilitate learning activities is the smartphone sensor application (Nazruddin, 2012).

Smartphones as special new media devices serving as tools for conducting experiments in classroom physics and daily life as well (Kuhn & Vogt, 2017). The smartphone is also a durable and multifaceted device that can precisely, conveniently, and consistently gauge physical quantities such as magnetic fields, acceleration, and angular velocity. On one hand, smartphone sensors create an opportunity to introduce a new paradigm in physics pedagogy (Shakur & Kraft, 2016). It also permits educational institutions to have low-cost laboratories and allows the students to make measurements of physical phenomena outside the teaching laboratories. Furthermore, Listiaji et al. (2020) compared an oscillation experiment using a video tracker and smartphone acceleration sensors and found that experiments using smartphone acceleration sensors obtain more precise results.

On the other hand, by using smartphones learning is being included as a routine aspect of the students' daily activities. They can use their devices to find out how the concepts learned in the classroom apply to their lives (Gonzalez et al., 2014). Shakur and Kraft (2016) also found that students take enormous pride in the data generated by their smartphones and are excited and motivated to learn from them.

With that being said, learning activities using smartphone sensor technology is getting more popular in Indonesia, using Phyphox (Physical Phone Experiments) as one of the application. This application provides a simple way of utilizing modern smartphone sensors for Android and iOS operating systems. In a study, Palacio et al. (2013) found success in demonstration and experiments using a smartphone sensor in the general physics laboratory. They use mobile phone accelerometers to study two-dimensional motions on an air table and various types of pendulum motions (Palacio et al., 2013).

Thus, this research aims to determine the attitude of undergraduate engineering students towards the use of Phyphox in physics experiments as well as determine the level of satisfaction with Phyphox application during experiments or lectures. The research questions are as follows:

1. What are undergraduate engineering students’ attitudes towards the use of Phyphox in physics experiments?
2. Are there any differences in attitude towards the use of Phyphox in physics experiments on students with various backgrounds?

Students' attitude

Although many studies have investigated students' attitudes toward science, there is no common definition of "attitude" (Kind et al., 2007; Osborne et al., 2003). Attitude toward learning science has been a well-researched domain for more than four decades (Chua & Karpudewan, 2017). Osborne et al. (2003) defined attitude as feelings, beliefs, and values held about an object that might be the enterprise of science, school science, and the impact of science on society or scientists themselves. Other researchers have claimed that attitude concerns emotional feelings such as good or bad, pleasant or unpleasant (Kind et al., 2007). According to Reid (2006), attitudes have interrelated cognitive, affective, and behavioral components. He defined the cognitive component as knowledge about an object, event, or concept, the affective component as feelings or emotions (e.g., like or dislike) about an object, and the behavioral component as behavior based on a person's attitude toward an object or an event (Reid, 2006). Young (1998) also emphasized the affective aspect of attitudes and stated that this is long-lived and related to behavior.

In short, attitude relates to the degree to which a person perceives something as important and believes that others should perceive so. Attitude is also a personal factor that refers to one's positive or negative judgment about a concrete subject. In this study, students' attitude is defined as one's perception of self, combined with beliefs and emotions in using a learning media, in this case, Phyphox, which constitutes the affective domain of a student. However, some external variables related to the learning system and student characteristics may also affect students' decision to either accept or reject a technology itself in a lesson (Matyokurehwa et al., 2020).

Some researchers argued that achievement as well as the nature of instruction are key factors, that affect students' attitudes towards science subjects and vice versa (Simpson & Oliver, 1990). Attitude is defined as a mental and emotional entity that characterizes a person's actions or thoughts toward a subject (Perloff, 2016). Moreover, a few studies that explore distinct emotional areas in science education have demonstrated a strong correlation between a student's attitude and academic performance in a particular subject.

Attitude, which is part of the affective domains, has been thoroughly studied in modern science for many decades. This is due to the strong correlation between attitude and other factors such as science learning, achievement, and even interest in pursuing science-related careers. Kapici et al. (2020) stated that students' interest in science has decreased dramatically, and careers related to science and technology have become less attractive in recent decades. Furthermore, the environment in which students do laboratory experiments can also influence their attitudes toward the application itself. As Penn & Mavuru (2020) state, laboratory experimentation is a worthy tool to enhance not only students' attitudes but also their procedural and conceptual understandings of science concepts in general. Thus, students' attitude towards the use of Phyphox is a key factor that encourages their interest in learning science through experiments. Several factors known to impact students' attitudes toward the use of Phyphox are researched in this paper, such as gender, smartphone type, major taken by students (department), and prior experience of using Phyphox.

Phyphox

The name of the application, Phyphox, is an acronym for “Physical Phone Experiments”. The app has been accessible on both the Google Play Store and Apple App Store since September 2016. Kousloglou et al. (2022) mention that Phyphox uses the phone’s built-in sensors, such as an accelerometer, magnetometer, gyroscope, etc. Furthermore, Phyphox tools offer remote access via a laptop or another digital mobile device and can export data in Excel-compatible format so that data can be processed to produce graphs (Kousloglou et al., 2022).

The usefulness of Phyphox has been acknowledged in many scientific articles. The application contains a lot of experiments that are built in (Figure 1). Also, Phyphox is an open-source application that provides limitless experiments beyond the built-in ones, allowing students and teachers to utilize raw data in creative and innovative ways, even connecting it to Arduino. The Phyphox application can be used for various learning models and is practically used as a laboratory. The app can also remotely connect to a personal computer to provide live data at a distance (Carroll & Lincoln, 2020). In conclusion, experiments using the Phyphox application can make students independent in experimenting (Mayampoh et al., 2020)

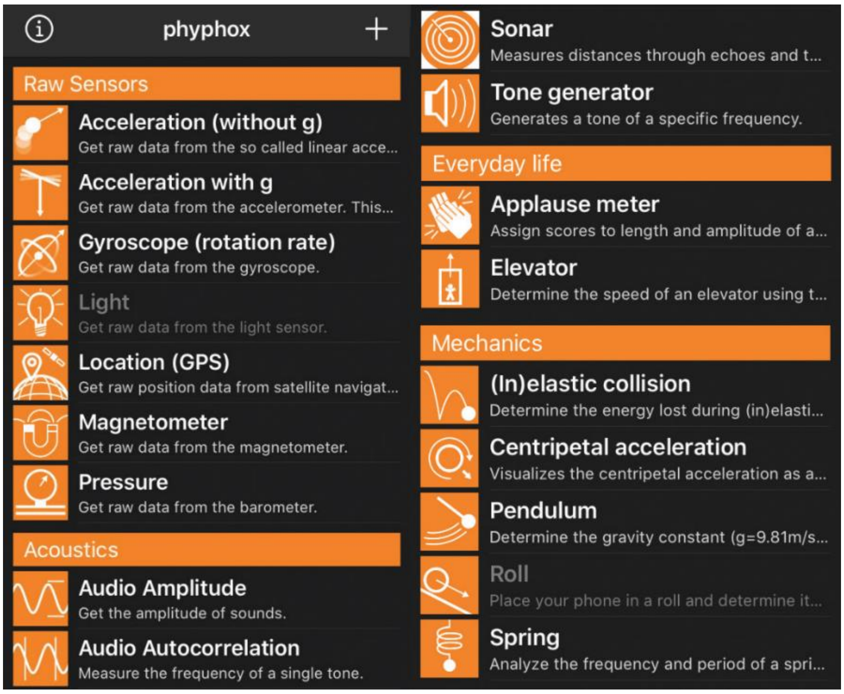

Figure 1. The main interface of the Phyphox app

Physics experiment

Physics is a science that studies very external aspects ranging from simple things to covering the universe, where it requires a critical, innovative, and creative thought process. This action, of course, requires adequate learning support, which is, of course, to create interactive and exciting learning for students. In this case, of course, the role of technology is very influential in increasing understanding of the learning concepts presented to achieve maximum learning outcomes and learning achievement (Supardi et al., 2015). Therefore, this aspect aims to provide a theory of extension or specification of environment-based learning (aspects that exist today: thematic, episodic, social) (Kuhn et al., 2011).

Physics is a subject that combines theoretical concepts with practical experiments and mathematical analysis. Physics investigates the existing phenomena and subsequently formulates them into physical principles, which are then developed into laws or theories, and tested or verified through experiments. Experimental activities can provide an enjoyable and friendly way for students to gain, integrate, and construct knowledge. Therefore, experimental or laboratory activities have an important role at all levels of education (Ilmi et al., 2021)**.** With the development of technology, lab practices are designed to cover different Physics areas and open the door to students to carry out their experiments at home by exploiting the technology implemented in their smartphones. The different sensors available in smartphones are useful tools for possible applications in experimental measurements and scientific demonstrations (Sans et al., 2015).

Method

The faculty of engineering at Trisakti University has implemented Phyphox as a new medium for practical activities pertaining to physics-related material. This research aimed to identify the attitude of undergraduate engineering students toward the use of Phyphox in physics experiments and determine the different students' attitudes with various backgrounds. In this study, participants are undergraduate engineering students from Trisakti University in Indonesia which are separated into seven departments, industrial engineering, mechanical engineering, electrical engineering, mine engineering, geological engineering, environmental engineering, and civil engineering. Those departments have introductory physics experiment course in the first and second year which is included in the university's curriculum.

For collecting data, a self-developed questionnaire for surveying was used as the main data-gathering instrument with two distinct sections. The first section collected information on the participants' backgrounds, while the second section was formulated to obtain and collect their attitudes toward the use of Phyphox. Four participants' backgrounds were developed to recognize the differences of each participant, while ten five-point Likert scale questions were advanced to identify the uses of Phyphox in the physics experiment. To ensure that the participants were eligible to respond to the research question, we opted to disseminate this questionnaire through an online platform to the faculty of engineering, at Trisakti University, Indonesia.

The questionnaire's validity was established through content validation, wherein the draft was evaluated by two lecturers and two teachers to guarantee the accuracy, comprehensiveness, non-overlapping nature, and ability to measure what was claimed. To ascertain reliability, Cronbach's alpha was employed, resulting in a score of .956 for the attitude toward Phyphox utilization. This score surpassed the .7 threshold, indicating an exceptionally high level of internal consistency for the questions.

The major software package for analyzing the data was Statistical Package for the Social Science (SPSS) version 24.0. Cronbach's alpha was first utilized to ensure the internal consistency or reliability of the questionnaire, and then, mean and standard deviation were utilized to illustrate the attitude of undergraduate engineering students toward the use of Phyphox in physics experiments. Lastly, an independent sample t-test and one-way ANOVA were adopted to measure the difference in attitude scores related to the use of Phyphox among students with various backgrounds.

To secure a high response rate, an experiment was conducted wherein students initially performed a mainstream experiment in a physics laboratory without the application of Phyphox. Following this, one month later, the same students executed a similar experiment using Phyphox on the same topic. The questionnaires were delivered to respondents in the classroom by the lecturers, collected, and subsequently mailed to the teachers (colleagues). The data was compiled and organized into a designated folder to be processed.

Out of the 200 questionnaires distributed, 185 valid questionnaires were returned, resulting in a response rate of 92.5%. The respondents consisted of 82 males and 103 females. Among them, 67 participants used an iPhone, while 118 participants used an Android operating system on their smartphones. Additionally, 49 participants studied industrial engineering, 18 participants studied mechanical engineering, 18 participants studied electrical engineering, 35 participants studied mining engineering, 12 participants studied geological engineering, 26 participants studied environmental engineering, and 27 participants studied civil engineering. Lastly, 54 participants reported having tried using the Phyphox application in a practical activity or another physics-related activity, while 131 participants had not.

Findings

This research focused on identifying the most important of utilizing Phyphox. The following section presents the findings related to the use of Phyphox and the differences in attitudes among students.

Use of Phyphox

As illustrated in Table 1, our research finding indicated that undergraduate engineering students highly recognized the use of Phyphox in physics experiments. The item “students are interested in using the Phyphox application for other practical activities” obtained the highest score of 4.24, followed by “the titles of content in the Phyphox application are well structured so that students can distinguish the types of experiment” and “students can retrieve accurate experiment data using the Phyphox application”, with the same score of 4.19, respectively. Meanwhile, “students did not find any technical problems such as crashes, stuttering, loading, or hangs when using the Phyphox application” and “students do not need any special technology skills to use the Phyphox application” were comparatively less recognized as the use of Phyphox by students.

Table 1. Use of Phyphox in a physics experiment

Factors		Mean	SD
1.	Students are motivated to carry out practical activities using the Phyphox application.	4.14	.813
2.	Students are interested in using the Phyphox application for other practical activities.	4.24	.799

3.	Students prefer doing experiments using the Phyphox application compared to conventional measuring instruments.	4.08	.853
4.	The measurement results in data in the form of graphs and tables are of good quality (the scale and numbers are legible)	4.16	.777
5.	The graphs and tables downloaded from the Phyphox application help students understand physics concepts.	4.14	.813
6.	All navigation and menus in the Phyphox application are easy to operate.	4.12	.774
7.	The titles of content in the Phyphox application are well structured so that students can distinguish the types of experiments.	4.19	.837
8.	Students can retrieve accurate experiment data using the Phyphox application.	4.19	.775
9.	Students do not need any special technology skills to use the Phyphox application.	4.01	.921
10.	Students did not find any technical problems such as crashes, stuttering, loading, or hangs when using the Phyphox application.	4.03	.850

Different attitudes of students toward on use of Phyphox

We were focused on identifying differences in attitude among students with diverse backgrounds. The different attitude of students towards on use of Phyphox is presented in Table 2 and Table 3. An independent-sample t-test was performed to compare the effect of gender, type of smartphone, and prior experience as presented in Table 2. First of all, male students indicated a greater degree of opinion than female students on “the titles of content in the Phyphox application are well structured so that students can distinguish the types of experiment” (t-value = 2.15; sig = .033).

Another interesting finding is that male students indicated a greater degree of opinion that they can retrieve accurate experiment data using the Phyphox application (t-value = 2.01; sig = .045), while also thinking that they do not need any special technology skills to use the Phyphox application (t-value = 2.13; sig = .035). This finding may indicate that male students possess better technical skills in measuring physical quantity using Phyphox. However, no difference in attitude was found in students who use different types of smartphones. These findings carry significance as it was assumed that many students decided not to opt for the Phyphox application in their physics experiment because they had different types of operating systems on their smartphones.

Furthermore, students with prior experience in using the Phyphox application showed that they are more motivated to carry out practical activities using the Phyphox application (t-value = 2.36; sig = .020), They also show higher preference in doing experiments using the Phyphox application compared to conventional measuring instruments (t-value = 3.92; sig = .000), and think that the measurement results data in the form of graphs and tables are of good quality (the scale and numbers are legible) (t-value = 3.03; sig = .003).

Moreover, students with prior experience are also of the higher opinion that the graphs and tables help them to understand physics concepts (t-value = 3.64; sig = .000), navigation and menus are easy to operate (t-value = 3.28; sig = .001), and the contents are well structured that they can distinguish the types of the experiment (t-value = 3.69; sig = .000). They are also of the higher opinion that they can retrieve accurate experiment data using the application (t-value = 3.16; sig = .002) without any special technology skills to use it (t-value = 4.10; sig = .000), and without finding any technical problems when using it (t-value = 3.99; sig = .000).

However, both students with and without prior experience show high interest in using the Phyphox application for other practical activities, i.e. no significant difference is found. This result indicates that prior experience does not affect the students' interest in using the Phyphox application, since students' overall attitude in using the Phyphox application is positive.

Table 2. Result of t-test on attitude variances among students

Factors		Gender 1 Male 2 Female	Smartphone 1 iPhone 2 Android	Prior Experience 1 Yes 2 No
1.	Students are motivated to carry out practical activities using the Phyphox application.			t = 2.36* 1 > 2
2.	Students are interested in using the Phyphox application for other practical activities.			
3.	Students prefer doing experiments using the Phyphox application compared to conventional measuring instruments.			t = 3.92*** 1 > 2
4.	The measurement results data in the form of graphs and tables are of good quality (the scale and numbers are legible).			t = 3.03** 1 > 2
5.	The graphs and tables downloaded from the Phyphox application help students to understand physics concepts.			t = 3.64*** 1 > 2
6.	All navigation and menus in the Phyphox application are easy to operate.			t = 3.28** 1 > 2
7.	The titles of content in the Phyphox application are well structured so that students can distinguish the types of experiments.	t = 2.15* 1 > 2		t = 3.69*** 1 > 2
8.	Students can retrieve accurate experiment data using the Phyphox application.	t = 2.01* 1 > 2		t = 3.16** 1 > 2
9.	Students do not need any special skills in technology to use the Phyphox application.	t = 2.13* 1 > 2		t = 4.10*** 1 > 2
10.	Students did not find any technical problems such as crashes, stuttering, loading, or hangs when using the Phyphox application.			t = 3.99*** 1 > 2

Moving on, a one-way ANOVA was carried out to compare the effect of seven departments in the faculty of engineering to the students' attitude as illustrated in Table 3. We found that industrial engineering students show significant differences in attitude compared to other engineering students in all factors, except "Students prefer doing experiments using the Phyphox application compared to conventional measuring instruments", "The graphs and tables downloaded from the Phyphox application help students to understand physics concepts", "Students do not need any special technology skills to use the Phyphox application", and "Students did not find any technical problems such as crashes, stuttering, loading, or hangs when using the Phyphox application". In those four factors, there is no significant difference in attitude between students of different engineering courses.

Using one-way ANOVA, it is also revealed that there are at least two groups with significant differences in the following four factors: "Students are motivated to carry out practical activities using the Phyphox application" ($F(6, 178) = [2.72]$, $p = .015$), "Students are interested in using the Phyphox application for other practical activities" ($F(6, 178) = [2.46]$, $p = .026$), "The titles of content in the Phyphox application are well structured so that students can distinguish the types of experiment" ($F(6, 178) = [2.67]$, $p = .017$), and "Students can retrieve accurate experiment data using the Phyphox application" ($F(6, 178) = [3.26]$, $p = .005$).

It is also revealed using one-way ANOVA, that there are at least three groups with significant differences in the following two factors: "The measurement results data in the form of graphs and tables are of good quality (the scale and numbers are legible)" with score ($F(6, 178) = [3.36]$, $p = .004$), and "all navigation and menus in the Phyphox application are easy to operate" with score ($F(6, 178) = [4.09]$, $p = .001$).

Furthermore, using Tukey's HSD (Honestly Significant Difference) Test for multiple comparisons we found in all six factors that industrial engineering students show significant differences with students from electrical engineering, mine engineering, environmental engineering, and civil engineering. Industrial engineering students show a significant difference compared to electrical engineering in "students are motivated to carry out practical activities using the Phyphox application" ($p = .026$, 95% C.I. = [-1.35, -.05]), with post hoc comparisons indicating mean score for electrical engineering ($M = 3.67$, $SD = .97$) that was significantly different than industrial engineering ($M = 4.37$, $SD = .81$).

Industrial engineering students also show a significant difference compared to civil engineering in "students are interested in using the Phyphox application for other practical activities" ($p = .032$, 95% C.I. = [-1.15, -0.03]). Post hoc comparison shows a significant difference in mean score for industrial engineering ($M = 4.55$, $SD = .74$) and civil engineering ($M = 3.96$, $SD = .71$).

Tukey's HSD Test for multiple comparisons found that in "the measurement results data in the form of graphs and tables are of good quality (the scale and numbers are legible)" there were significant differences between mine engineering and industrial engineering ($p = .008$, 95% C.I. = [-1.09, -.10]), also between civil engineering and industrial engineering ($p = .041$, 95% C.I. = [-1.08, -.01]). Post hoc comparisons using the Tukey HSD test indicated that the mean score for industrial engineering ($M = 4.51$, $SD = .68$) was significantly different than mine engineering ($M = 3.91$, $SD = .74$) and civil engineering ($M = 3.96$, $SD = .76$).

With the same Tukey's test, we also found that "all navigation and menus in the Phyphox application are easy to operate" were significantly different between mine engineering and industrial engineering (p = .017, 95% C.I. = [-1.03, -.06]), also between environmental engineering and industrial engineering (p = .007, 95% C.I. = [-1.18, -.11]). Post hoc comparisons using the Tukey HSD test indicated that the mean score for industrial engineering (M = 4.49, SD = .71) was significantly different than mine engineering (M = 3.94, SD = .77) and environmental engineering (M = 3.84, SD = .61).

Moreover, industrial engineering students show significant difference compared to electrical engineering in "students are motivated to carry out practical activities using the Phyphox application" (p = .026, 95% C.I. = [-1.35, -.05]), with post hoc comparisons indicating mean score for electrical engineering (M = 3.67, SD = .97) that was significantly different than industrial engineering (M = 4.37, SD = .81).

Industrial engineering students show significant difference compared to environmental engineering students in "the titles of content in the Phyphox application are well structured so that students can distinguish the types of experiment" (p = .016, 95% C.I. = [-1.25, -.07]), with post hoc comparisons indicated mean score for environmental engineering (M = 3.85, SD = .78) that was significantly different than industrial engineering (M = 4.51, SD = .68).

Lastly, using Tukey's HSD Test for multiple comparisons also found that "students can retrieve accurate experiment data using the Phyphox application" was significantly different between mine engineering and industrial engineering (p = .037, 95% C.I. = [-1.00, -¬.02]). Post hoc comparisons using the Tukey HSD test indicated that the mean score for mine engineering (M = 4.00, SD = .73) was significantly different than industrial engineering (M = 4.51, SD = .71).

Table 3. Result of ANOVA on attitude variances among students

	Factors	Departments	F	Post Hoc
1.	Students are motivated to carry out practical activities using the Phyphox application.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	2.72*	1 > 3
2.	Students are interested in using the Phyphox application for other practical activities.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	2.46*	1 > 7
3.	Students prefer doing experiments using the Phyphox application compared to conventional measuring	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering	1.59	

	instruments.	(7) Civil Engineering		
4.	The measurement results data in the form of graphs and tables are of good quality (the scale and numbers are clearly legible)	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	3.36**	1 > 7 1 > 4
5.	The graphs and tables downloaded from the Phyphox application help students to understand physics concepts.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	2.84	
6.	All navigation and menus in the Phyphox application are easy to operate.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	4.09**	1 > 4 1 > 6
7.	The titles of content in the Phyphox application are well structured so that students can distinguish the types of experiment.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	2.67*	1 > 6
8.	Students can retrieve accurate experiment data using the Phyphox application.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	3.26**	1 > 4
9.	Students do not need any special skills in technology to use the Phyphox application.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	1.63	
10.	Students did not find any technical problems such as crashes, stuttering, loading, or hangs when using the Phyphox application.	(1) Industrial Engineering (2) Mechanical Engineering (3) Electrical Engineering (4) Mine Engineering (5) Geological Engineering (6) Environmental Engineering (7) Civil Engineering	1.84	

Discussion

The objective of this research was to identify the major attitude of using Phyphox application in physics practical activity in the faculty of engineering, at Trisakti University, Indonesia. The research findings showed that, in general gender does not correlates with students' attitude towards the use of Phyphox in physics experiment. Gender only has a significant difference in three out of ten factors of attitude in this research. It should be noted that the three factors were related to the technical aspect of using Phyphox and retrieving data from it.

Similarly, the types of smartphones owned by the students also do not correlate with students' attitudes. This might indicate that the Phyphox application has been designed to run on iOS and Android OS properly. However, it should be noted that the accuracy and precision of Phyphox experiment data depend entirely on the hardware aspect of the smartphone, which we did not take into account in this research.

Moving on, the result shows that students with prior experience in using Phyphox show an overall higher score of attitude compared to students without prior experience. This finding might indicate that the more students use Phyphox in learning, the better their attitude towards it. It should be noted that students' interest in using Phyphox is not significantly different among students with different prior experiences, which is all positive.

Lastly, we found that students' course background relates to some of the factors of attitude in using Phyphox. Out of seven departments of engineering students, five show significant differences in attitude. We found that, in most factors of attitude, industrial engineering students show a significantly higher attitude towards the use of Phyphox in a physics experiment.

Conclusion

Just like how different people use smartphones differently, different students also have different attitudes toward the use of Phyphox. The research found that gender and the type of smartphone owned by the students did not significantly affect the students' attitudes towards using Phyphox in physics experiments. However, the research revealed that students with prior experience in using Phyphox showed a higher overall attitude score compared to students without prior experience.

Additionally, students' course background was found to relate to some of the factors of attitude in using Phyphox, with industrial engineering students showing significantly higher attitudes towards the use of Phyphox in physics experiments compared to students of other engineering departments. Further research is needed to determine what makes industrial engineering students stand out compared to students in other engineering departments.

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