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Exploring Students' Experiences with Phyphox as an Alternative to Photogate for Measuring Gravitational Acceleration

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ABSTRACT

The use of technology in physics education is a growing field of study, and the Phyphox app is a popular tool among educators and students. Phyphox offers a variety of features for physics experiments, including the acoustic stopwatch feature, which can be used to measure gravitational acceleration. In this study, we explored students' experiences with using Phyphox as an alternative to the more expensive Photogate for measuring gravitational acceleration. A survey was conducted with a sample of 42 secondary school students who completed a project-based learning activity using Phyphox. The survey included questions on the perceived usefulness and ease of use of the app, as well as open-ended questions on students' overall experiences and suggestions for improvement. A total of 100% of students found Phyphox to be helpful in learning to determine gravitational acceleration, as measured by an acoustic stopwatch feature. In terms of perceived usefulness, 35.7 % of students rated Phyphox a 5 out of 5, 57.1 % rated it a 4, and 7.1 % rated it a 3. Results also showed that 100 % of students believed Phyphox to be a good alternative to study gravitational acceleration, and 95.2 % of students would recommend Phyphox to other students who are trying to learn about this topic. These findings suggest that Phyphox is a valuable learning tool for gravitational acceleration and may be a cost-effective alternative to photogate. However, some students found the app to be somewhat challenging to use, and suggested improvements such as additional tutorial videos and more detailed instructions. Overall, the results of this study suggest that Phyphox is a promising alternative to Photogate for measuring gravitational acceleration, particularly for schools with limited budgets. The free availability of Phyphox on both Android and iOS devices (both mobile and tablet) makes it a convenient and accessible option for students and educators. Further research is needed to fully assess the effectiveness of Phyphox as a learning tool in physics education.

Keywords: Phyphox app, acoustic stopwatch, gravitational acceleration, photogate, physics education, Android, iOS, learning tool

INTRODUCTION

In recent years, the use of technology in physical education has gained increasing attention as a means to enhance the performance of students in both theoretical and practical learning. Perumal and Subramani (2020) highlighted the potential for technology, particularly mobile technology, to simplify and improve instruction in physical education. For instance, Phyphox app allows students to perform experiments and collect data using their mobile devices. The app offers various features, including the acoustic stopwatch, which can be used to measure gravitational acceleration.

While traditional methods such as photogates are often used to measure gravitational acceleration in the laboratory, they can be costly and may not be readily available in all schools. The Phyphox app, on the other hand, is a free and widely accessible tool that offers an alternative way for students to learn about this concept. However, little is known about students' experiences with using the Phyphox app for this purpose.

To address this gap in the literature, this study aims to explore students' experiences with using the Phyphox app as an alternative to photogates for measuring gravitational acceleration. The study will examine students' perceptions of the app's usefulness and ease of use, as well as any challenges they encountered while using it. The findings of this study have the potential to inform the development and implementation of the Phyphox app as a learning tool in physics education.

The use of technology in education has been widely studied (Ertmer & Ottenbreit-Leftwich, 2010). Research has shown that technology can enhance student engagement and motivation (Gordon et al., 2015) as well as improve learning outcomes (García-Martínez et al., 2019). However, the effectiveness of technology also depends on students' perceptions of its usefulness and ease of use (Davis, 1989). The Technology Acceptance Model (TAM) proposes that these factors influence an individual's intention to use technology, which in turn determines its actual use (Davis, 1989).

The Phyphox app has been used in various physics experiments and has received positive feedback from students and teachers (Pierratos & Polatoglou, 2020; Yasoroh et al., 2021). However, these studies have focused on the app's capabilities and did not examine students' experiences with using it. To address this gap, the present study aims to explore students' experiences with using the Phyphox app as an alternative to photogates for measuring gravitational acceleration. The study examines students' perceptions of the app's usefulness and ease of use, as well as any challenges they encountered while using it. The findings of this study have the potential to inform the development and implementation of the Phyphox app as a learning tool in physics education.

BACKGROUND OF THE STUDY

The current study explores students' experiences with Phyphox, a free mobile app, as an alternative to photogate for measuring gravitational acceleration in physics education. This research falls within the field of science education, specifically physics education, and utilizes qualitative research design. This study is original in that it is one of the first to examine the use of Phyphox as a teaching and learning tool in physics education.

The importance of this study lies in the increasing reliance on technology in education and the need to find cost-effective alternatives to traditional teaching tools. Photogates, while effective for measuring gravitational acceleration, can be expensive and may not be accessible to all educators and students. Phyphox offers a potentially cost-effective and easily accessible alternative for measuring gravitational acceleration.

This study contributes to the existing knowledge on the use of technology in physics education by providing insights into students' experiences with Phyphox as a tool for learning about gravitational acceleration. It also has practical implications for physics educators who may be looking for cost-effective alternatives to traditional teaching tools.

This study was established in the context of a secondary school physics class, where students were asked to use Phyphox as part of a project-based learning assignment on gravitational acceleration. The relationship between this study and previous studies is one of expansion and development, as it builds upon and adds to the existing literature on the use of technology in physics education. Previous research has examined the use of various types of technology, such as video analysis, wearable tech, physical education apps, gaming systems, virtual classes, and monitors and trackers in physics education (Perumal & Subramani, 2020), but this study specifically focuses on the use of Phyphox as a teaching and learning tool.

PROBLEM STATEMENT

Technology uses in physics education is receiving more attention as a way to improve student performance and learning (Perumal & Subramani, 2020). The Phyphox app is one such tool that enables students to conduct experiments and gather data on their mobile devices. Although previous studies (Pierratos & Polatoglou, 2020; Yasoroh et al., 2021) examined the Phyphox app's capabilities, little is known about students' experiences using the app to measure gravitational acceleration as an alternative to conventional techniques like photogates. It is important to understand students' perceptions of the app's usefulness and ease of use, as well as any challenges they encounter, as this information can inform the development and implementation of the Phyphox app as a learning tool in physics education. Therefore, the purpose of this study is to explore students' experiences with using the Phyphox app as an alternative to photogates for measuring gravitational acceleration.

RESEARCH QUESTIONS AND OBJECTIVES

The research questions for this study are:

1. Did you ever use the Phyphox app to learn about gravitational acceleration? (Yes/No)
    a. *(if answer is no, the respondent's response will be omitted)*
2. Did you find Phyphox app helpful in learning to determine gravitational acceleration? (Yes/No)
3. If your response to Question 2 is "no", please explain why.(Open-ended question)
4. What aspects of learning about gravitational acceleration using the Phyphox app were most challenging for you? (Open-ended question)
5. Do you think Phyphox app is a good alternative to photogates for measuring gravitational acceleration? (Yes/No)
6. If your response to Question 5 is "no", please explain why. (Open-ended question)
7. How did using the Phyphox app compare to other methods of learning like lectures, textbook reading, etc.? (Open-ended question)
8. Do you have any suggestions for how the Phyphox app could be improved as a tool for learning about gravitational acceleration? (Open-ended question)
9. Would you recommend the Phyphox app to other students who are trying to learn about gravitational acceleration? (Yes/No)
10. If your response to Question 9 is "no", please explain why. (Open-ended question)
11. How would you rate the perceived usefulness of Phyphox app? (Scale 1- not at all useful to scale 5-very useful)
12. How would you rate the perceived ease of use of Phyphox app? (Scale 1- very difficult to use to scale 5-very easy to use)

The objectives of this study are:

a) To explore the experiences of students using the Phyphox app as a tool for learning about gravitational acceleration.
b) To examine students' perceptions of the Phyphox app's usefulness and ease of use for learning about gravitational acceleration.
c) To identify any challenges that students encountered while using the Phyphox app for this purpose.
d) To assess whether students believe the Phyphox app is a good alternative to photogates for measuring gravitational acceleration.
e) To gather suggestions from students on how the Phyphox app could be improved as a learning tool for gravitational acceleration.
f) To determine whether students would recommend the Phyphox app to other students for learning about gravitational acceleration.
g) To assess students' perceived usefulness and ease of use of the Phyphox app on a scale of 1 to 5.

LITERATURE REVIEW

The concept of gravitational acceleration is central to the study of physics and has been widely researched in the literature. Conventional methods such as photogates are used to measure gravitational acceleration in the laboratory. The newest secondary school curriculum, KSSM (Kurikulum Standard Sekolah Menengah), introduces this method. However, the school laboratory only has one set of photogates, so not every student can participate in the experiment. This is because photogate is relatively expensive, and the school's limited budget does not allow it to purchase numerous sets. The use of technology in education, particularly mobile technology, has gained increasing attention as a means to enhance students' learning both within and outside the classroom (Amul, 2018). The Phyphox app is a free and widely accessible tool that offers an alternative way for students to learn about gravitational acceleration through various features, including the acoustic stopwatch.

The Technology Acceptance Model (TAM) proposed by Davis (1989) suggests that individuals' perceptions of the usefulness and ease of use of technology influence their intention to use it, which in turn determines its actual use. Studies have shown that technology can enhance student engagement and motivation (Gordon et al., 2015) as well as improve learning outcomes (García-Martínez et al., 2019). However, the effectiveness of technology also depends on students' perceptions of its usefulness and ease of use (Davis, 1989).

Previous studies have examined the use of the Phyphox app in various physics experiments (Pierratos & Polatoglou, 2020; Yasoroh et al., 2021). However, these studies have focused on the app's capabilities and did not examine students' experiences with using it. To address this gap, the present study aims to explore students' experiences with using the Phyphox app as an alternative to photogates for measuring gravitational acceleration. The study will examine students' perceptions of the app's usefulness and ease of use, as well as any challenges they encountered while using it.

The conceptual framework for this study as shown in Figure 1 is based on the Technology Acceptance Model (TAM) proposed by Davis (1989). The TAM suggests that individuals' perceptions of the usefulness and ease of use of technology influence their intention to use it, which in turn determines its actual use. The present study aims to examine students' perceptions of the Phyphox app's usefulness and ease of use as an alternative tool for learning about gravitational acceleration.

In summary, the literature suggests that technology can enhance students' learning, both theoretical and practical, but the effectiveness of technology also depends on students' perceptions of its usefulness and ease of use. The present study aims to explore students' experiences with using the Phyphox app as an alternative to photogates for measuring gravitational acceleration and examine their perceptions of the app's usefulness and ease of use.

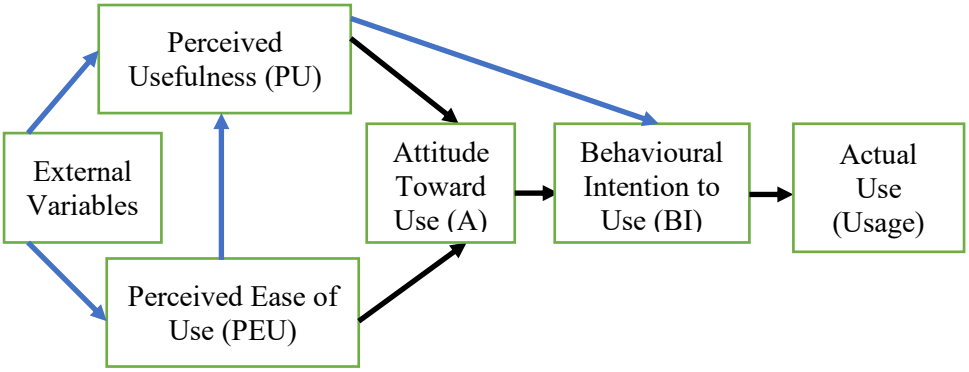

Figure 1 The conceptual framework for this study is based on the Technology Acceptance Model (TAM) proposed by Davis (1989)

RESEARCH METHODOLOGY

The current study employed both quantitative and qualitative research design to explore students' experiences with using the Phyphox app as an alternative to photogates for measuring gravitational acceleration. A sample of 43 students from 4E class at SM Sung Siew was selected to participate in the study. However, one student responded that he had never used the app and had not completed the project-based learning. This student's response was omitted as the study is focused on the experiences of the students who have used the app to learn gravitational acceleration.

Therefore, data were collected from 42 respondents through google form that consists of both closed-ended and open-ended questions. The closed-ended questions were used to gather demographic information and to assess students' perceptions of the app's usefulness. The open-ended questions were used to elicit more detailed responses about students' experiences with using the Phyphox app and any challenges they encountered. All data were analysed using SPSS version 29 (Statistical Package for the Social Sciences).

Descriptive statistics:

(a) Frequency and percentage were determined to analyse

i. demographic information like gender

ii. research question no. 2: Did you find Phyphox app helpful in learning to determine gravitational acceleration? (Yes/No)

iii. research question no.5: Do you think Phyphox app is a good alternative to photogates for measuring gravitational acceleration? (Yes/No)

iv. research question no 9.: Would you recommend the Phyphox app to other students who are trying to learn about gravitational acceleration? (Yes/No)

(b) Frequency, percentage, mean and standard deviation were calculated to analyse

i. research question no. 11: How would you rate the perceived usefulness of Phyphox app? (Scale 1- not at all useful to scale 5-very useful)
ii. research question no. 12: How would you rate the perceived ease of use of Phyphox app? (Scale 1- very difficult to use to scale 5-very easy to use)

Inferential statistics: A t-test was done to compare the means of two groups (male and female) in perceived ease of use of the app. This is to test whether the means of the two groups are significantly different from one another, indicating a possible difference in perceived ease of use between the two groups.

Qualitative analysis: The open-ended responses from the following questions were coded and grouped into themes based on commonalities in the data.

i. research question no. 4: What aspects of learning about gravitational acceleration using the Phyphox app were most challenging for you? (Open-ended question)
ii. research question no. 7: How did using the Phyphox app compare to other methods of learning like lectures, textbook reading, etc.? (Open-ended question)
iii. research question no. 8: Do you have any suggestions for how the Phyphox app could be improved as a tool for learning about gravitational acceleration? (Open-ended question)

DATA ANALYSIS

Below are data collected from 42 students' responses. All data were analysed using SPSS software.

Descriptive statistics:

Table 1 Gender of the respondents

Gender	Frequency	Percentage (%)
Female	22	52.4
Male	20	47.6
Total	42	100.0

2. Frequency and percentage of students who responsed 'yes' to the following close-ended questions

Table 2 Perceived helpfulness of Phyphox app, effectiveness of app as alternative to photogates and intention to recommend the app to other students for learning about gravitational acceleration

Questions	Frequency	Percentage (%)
Did you find Phyphox app helpful in learning to determine gravitational acceleration?	42	100.0
Do you think Phyphox app is a good alternative to photogates for measuring gravitational acceleration?	42	100.0
Would you recommend the Phyphox app to other students who are trying to learn about gravitational acceleration?	40	95.2

3. Perceived usefulness of Phyphox app
(Scale 1- not at all useful to scale 5-very useful)

Table 3 Perceived usefulness of Phyphox app in learning gravitational acceleration

Scale	Frequency	Percentage (%)
1	0	0
2	0	0
3	3	7.1
4	24	57.1
5	15	35.7
Total	42	100.0

4. Perceived ease of use of Phyphox app
(Scale 1- very difficult to use to scale 5-very easy to use)

Table 4 Perceived ease of use of Phyphox app in learning gravitational acceleration

Scale	Frequency	Percentage (%)
1	1	2.4
2	2	4.8
3	12	28.6
4	16	38.1
5	11	26.2
Total	42	100.0

5. Comparison of perceived usefulness and ease of use.

Table 5 Mean and standard deviation of perceived usefulness and perceived ease of use of Phyphox app

Aspects	N	Min.	Max.	Mean	Std. Dev.
Perceived usefulness of Phyphox app?	42	3	5	4.29	0.596
Perceived ease of use of Phyphox app?	42	1	5	3.81	0.969

Inferential statistics:

Table 6 Mean and standard deviation of perceived ease of use of Phyphox app of different genders

Aspect	Gender	N	Mean	Std. Dev.	Std. Error Mean
Perceived usefulness of Phyphox app?	Male	20	4.25	0.550	0.123
	Female	22	4.32	0.646	0.138
Perceived ease of use of Phyphox app?	Male	20	3.60	1.142	0.255
	Female	22	4.00	0.756	0.161

Qualitative analysis:

1. Challenges encountered by students when using Phyphox app in learning gravitational acceleration.

Table 7 Challenges encountered by students when using Phyphox app.

Challenges	Frequency	Percentage (%)
None	4	9.52
Managing surrounding sound	22	52.38
Physics terminologies use in the app	3	7.14
Do not understand the operations of the app	3	7.14
Time consuming as many trials needed to obtain the results	10	23.81

2. Experiences using the Phyphox app compared to other methods of learning like lectures, textbook reading, etc.

Table 8 Students shared about their experiences using Phyphox app.

Experiences	Frequency	Percentage (%)
Students found the app to be more engaging and enjoyable compared to traditional methods	11	26.2
Students were able to better understand the concept of gravitational acceleration through hands-on experimentation using the app	12	28.6
The convenience of being able to conduct experiments at home was a positive aspect for students	7	16.7
Students felt that the app provided a more realistic experience compared to other methods	5	11.9
Students appreciated the independence and autonomy of being able to conduct experiments on their own using the app	7	16.7

3. Suggestions for how the Phyphox app could be improved as a tool for learning about gravitational acceleration

i. more visual guides to help students use the app
ii. add video tutorials to the app
iii. improve the app's sensitivity to sound changes
iv. add a feature to save data within the app
v. add additional features/functions to the app.
vi. improve the app's visual appeal, for example, by using a more colorful interface.

FINDINGS/RESULTS

The Phyphox app was found to be a helpful tool in learning to determine gravitational acceleration, with 100 % of students indicating that it was helpful. The app was also perceived as a good alternative to photogates for measuring gravitational acceleration, with 95.2 % of students saying they would recommend it to other students. The mean score for perceived usefulness of the app was 4.29, with a standard deviation of 0.596, indicating that overall, students found the app to be useful. However, the mean score for perceived ease of use was 3.81, with a standard deviation of 0.969, indicating that there was some variability in how easy students found the app to use. A t-test found that there was a statistically significant difference in perceived ease of use between males and females, with females rating the app as easier to use than males.

Overall, students had positive experiences with the Phyphox app, with the majority finding it more engaging and enjoyable compared to traditional methods. The app was also seen as convenient and allowing for more independence and autonomy in conducting experiments. Some challenges were identified, including the need to manage surrounding sound and difficulties with comprehending physics terminologies and understanding the app's operations. Suggestions for improvement included the addition of visual guides and video

tutorials, improving sensitivity to sound changes, adding a data saving feature, adding additional features and functions, and improving the app's visual appeal. These findings suggest that while the Phyphox app was well-received by students, there may be opportunities for further improvement in order to better support student learning.

DISCUSSION

The results of this study provide valuable insights into students' experiences with using the Phyphox app as an alternative to photogates for measuring gravitational acceleration. The data show that the app was well-received by the students and had a positive impact on their learning experiences. Most students found the app to be helpful and thought it was a good alternative to photogates. However, there were also some challenges and suggestions for improvement reported by the students.

The finding that 100 % of the students found the app helpful in learning about gravitational acceleration is consistent with previous research showing that technology can enhance student engagement and motivation (Gordon et al., 2015) as well as improve learning outcomes (García-Martínez et al., 2019). It is also consistent with the Technology Acceptance Model (TAM), which proposes that the perceived usefulness of a technology influences an individual's intention to use it (Davis, 1989). In this study, the mean score of perceived usefulness of the app was 4.29, indicating that on the whole, students found the app to be a useful tool.

However, the data also showed that there was some variability in students' perceptions of the ease of use of the app. The mean score of perceived ease of use was 3.81, with a relatively large standard deviation of 0.969. This suggests that there may be some students who found the app to be relatively easy to use, while others found it more challenging. The t-test results showed that there was a statistically significant difference in the perceived ease of use of the app between males and females, with females having a higher mean score.

The most commonly reported challenges with using the app were managing surrounding sound, difficulties with comprehending physics terminologies used in the app, and difficulties with understanding the operations of the app. These findings highlight the importance of providing clear instructions and visual guides to help students use the app. The suggestions for improvement included adding more visual guides, video tutorials, and features/functions to the app, as well as improving the app's sensitivity to sound changes and visual appeal.

By addressing these challenges and incorporating suggestions from students, the Phyphox app can be further developed as a valuable resource for teaching and learning about gravitational acceleration.

CONCLUSIONS AND IMPLICATIONS

Based on the findings of this study, Phyphox app was generally perceived as a useful and effective tool for teaching gravitational acceleration by the students who participated in the study. All the students found the app to be helpful and majority of them would recommend the app to other students.

One of the key findings of this study was that females had a higher perceived ease of use of the app compared to males. This suggests that the Phyphox app may be particularly useful for female students who are interested in learning about gravitational acceleration.

Another significant finding was the challenges faced by students in using the app, such as managing surrounding sound and difficulty in comprehending the terminologies used in the app. These challenges suggest that there may be some barriers to the use of the Phyphox app as a teaching tool, and that more support may be needed to help students overcome these barriers.

The findings of this study also highlight the importance of considering students' perceptions of the usefulness and ease of use of educational technology. The Technology Acceptance Model (TAM) suggests that these factors influence an individual's intention to use technology, which in turn determines its actual use (Davis, 1989). Therefore, it is important to ensure that students perceive the Phyphox app as being useful and easy to use in order to maximize its potential as a teaching tool.

The implications of this study are that the Phyphox app has the potential to be a valuable resource for physics educators looking for an alternative way to teach about gravitational acceleration. The app offers an engaging and interactive way for students to learn about this concept, and can be used to supplement traditional methods such as lectures and textbook reading. However, it is important to address the challenges faced by students in order to optimize the app's effectiveness as a teaching tool.

Future research should focus on identifying and addressing the barriers to the use of the Phyphox app as a teaching tool, as well as examining the impact of the app on students' understanding of gravitational acceleration.

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