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Application of Blended Learning with PhET Simulation to Encourage Learning in Mathematics of Fractions

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Abstract: Technology in education is essential for both teaching and learning. The purpose of this study is to correct mathematic misconception about the addition and subtraction of fractions, as well as explore students' attitudes toward using technology to learn mathematics. In this study, blended learning activities was used with PhET simulation. Both hands-on and digital technology activity were implemented. The findings of this study revealed better comprehension in students who learned with a blended learning activity with PhET simulation. In addition, there was a general improvement in students' attitudes toward using technology for learning mathematics. The results implied that using blended learning activity with technologies in mathematics classrooms could correct leaners' misconception as well as fostering positive attitudes toward learning mathematics in primary level.

Keywords: Mobile learning, attitude, blended learning, misconception.

1. Introduction

Technology can potentially enhance the teaching and learning of mathematics, leading to gains in higher-order thinking skills (Wenglinsky, 1998), as well as student achievements and self-efficacy (Mistretta, 2005). The National Council of Teachers of Mathematics (2000) explained, "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student learning". Adewuyi (2001) noted that the style of teaching employed by teachers is a potent factor in motivating learners to learn; mathematics is a subject that is very easy to make difficult and very difficult to make easy. The perennial methods of teaching mathematics through listening, looking, and learning have failed. If anything, it has made students dislike mathematics (Akinsola, 2002). The current teaching and learning of mathematics include technology, such as using applications to calculate answers or playing math games through various websites and applications to review knowledge or import into lessons before learning begins or can be used in organizing learning activities that excite students about learning. Learning mathematics through simulations is another way for students to learn about technology. Simulations, such as PhET (https://phet.colorado.edu), provide a dynamic nature to multiple representations by making abstract concepts concrete, supporting an inquiry environment, and allowing for multiple trials and rapid feedback cycles, while also being engaging and enjoyable for students and teachers (Meadows, 2019). Simulation-based learning, it can be applied to many learning management methods; for example, Akinsola et al. (2007) used a simulation-games environment that could improve students' achievements and attitudes toward mathematics. The study found that the poor academic achievement of students in mathematics is partly due to the teaching method used and that stimulating teaching methods such as simulation games can sustain and motivate students' interest in learning mathematics. The results of this research suggest that emphasizing the use of simulation games to teach mathematics can improve mathematics teaching and learning in schools. Both the use of technology and simulation in managing mathematics learning result in learning achievement and knowledge. The students'

understanding is going to improve. If the advantages of using various technologies are applied in mathematics classes, there could be many benefits. Blended learning is another method of teaching and learning that use technology and face-to-face teaching together.

Blended learning combines both face-to-face instruction and technologically based online instruction. It combines traditional and advanced online learning methods, such as chatrooms, podcasts, and live online lectures (Barrett & Sharma, 2007). By using blended learning, learners take lectures in a face-to-face class and can interact with each other through online platforms. These online learning experiences may replace classroom instruction, but interaction with peers and instructors is also possible on these platforms (Pandya and Shroff, 2022). The use of blended learning in education can enhance student learning and make the whole learning experience more enjoyable. Moreover, Indrapangastuti et al. (2021) demonstrated that blended learning is more effective than conventional learning in improving students' achievement of mathematical concepts.

In mathematics learning, most students had issues for understanding mathematical concepts. For example, Retnawati et al. (2011) reported that up to 88.57% of students have trouble understanding the mathematical concepts that they are supposed to be learning. Moreover, Waskitoningtyas (2016) found that there were lots of reasons why students have difficulty learning mathematics, such as a lack of interest in the subject, the need to learn numerous formulas, boring teaching methods, and teachers not paying enough attention to students with low levels of understanding. One of the concepts that students have difficulties with is fractions. Alghazo and Alghazo (2017) found that If students have misconceptions about fractions now, they will continue to have misconceptions in the future. Thus, Aksoy and Yazlik (2017) mentioned that students should learn about fractions because fractions are related to many other math topics, such as percentages, decimals, probability, and algebra. Therefore, to correct misconceptions in mathematics related to addition and subtraction of fractions, it is necessary to employ teaching methods that engage students' interest in learning. This will enable students to perceive correct mathematics concepts better and allow them to share their thoughts, engage in discussions, and exchange opinions in the classroom. Hence, the researchers utilized blended teaching with simulation from PhET on fraction concepts in mathematics classrooms.

2. Literature Review

2.1 Technology-supported Learning in Mathematics

Over the past two decades, there has been an increase in the use of high-tech tools in classrooms. A new generation of information teaching techniques has emerged that combines digital media, human-computer interaction, and educational technology. For example, Verzosa et al. (2022) studied the development of an app and videos to support fractions. They found that videos immerse learners in a range of fraction representations that can extend their initial part-whole understanding of the fraction concepts. In addition, Hsu (2020) used Virtual Reality for mathematics classrooms. The results showed that VR has the effect of improving students' learning motivation and learning effectiveness in the digital teaching of mathematics. Furthermore, computer simulation is one of the technologies which could help students use multiple representations, support their efforts to create knowledge, concentrate on conceptual ideas, and offer quick feedback (D'Angelo et al., 2014). Simulation is helpful not only because it can provide believable numerical answers but also, perhaps more importantly because it requires a comprehensive comprehension of the problem to be solved (Reinhardt & Loftsgadeen, 1979). Problems are often unique or inaccessible to students. For such cases, students may be able to use interactive simulations as a supplement or even a substitute for an experiment. For example, the study of Srisawasdi et al. (2015) examined the effect of the teaching method of simulation-based inquiry with a dual-situated learning model (SimIn-DSLM) on students' conceptual understanding. This finding suggests that the SimIn-DSLM method could be used. To induce a mechanism of change within students' conceptual knowledge of sound wave phenomena, and the change of their conceptions could place them

into the meaningful conceptual framework of basic scientific knowledge. Moreover, Arifin et al. (2022) studied the effectiveness of using PhET Simulation in primary school students' mathematical understanding of fractions. The results showed that using PhET Interactive Simulation significantly improved students' mathematical understanding of fractions. From the above, researchers focus on the technology used in simulation in mathematics teaching and learning. The use of simulations in teaching and learning can develop the students' competency.

2.2 Blended Learning in Mathematics

Traditional classroom instruction and online learning have been modified and progressively replaced with "Blended Learning." The concept of blended learning, which combines multiple instructional models, has garnered considerable attention in recent years. The Blended Learning approach has been applied to mathematics education at the elementary school level. Research by Indrapangastuti et al. (2021) demonstrated the effectiveness of using blended learning to enhance students' mathematics concepts. The study's results suggested that the blended learning model is significantly more effective than the conventional learning model for enhancing students' mathematical concept achievement. These findings match Jemakmun (2022) research on blended learning to improve mathematics abilities. This study found that the blended learning model with formative and summative assessments improved students' mathematics learning outcomes, especially for those with high early math abilities. Blended learning methods can be combined with other teaching methods. Yennita and Zukmadini (2019) studied blended learning and Problem-based learning to improve critical thinking skills and student learning activities. This study concludes that applying problem-based learning (PBL) using the blended learning method can improve critical thinking skills and student learning activities.

Due to recent technological advancements, Marsh and Drexler (2001) and Willett (2002) claimed that blended learning represents all teaching models integrated with technology, such as e-mails, streaming media, and the Internet, and can be combined with traditional teaching methods. The blended learning concept has been defined and developed alongside internet technology. Therefore, researchers attempted to use blended learning, combining teaching technologies with face-to-face (F2F) instruction to assist students in archiving their learning objectives and practicing both learning and working (Driscoll, 2010).

2.3 Misconceptions In Mathematics

Mathematics is one of the subjects taught at all educational levels. Students were typically introduced to mathematics at a young age. This is because mathematics has indirect effects on student activities. (Trivena et al., 2017) However, many students keep considering mathematics as a difficult and unattractive subject. If students believe that mathematics is relaxing, enjoyable, significant, and essential for their academic success and future, this will have a positive effect on their motivation to learn. Misconceptions and errors are possible. Other factors may include inexperience, difficulties in comprehending or interpreting inquiries, and a requirement for numerical literacy. A misconception, on the other hand, is the result of a misunderstanding or incorrect application of a rule or mathematical concept (Spooner, 2002). Errors are one method for measuring students' comprehension of concepts, problems, and procedures.

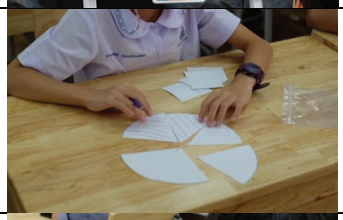
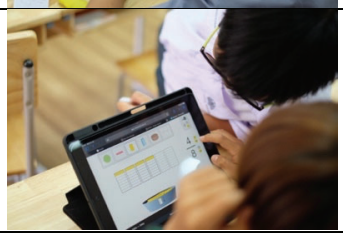
Fractions are one of the concepts with which students need assistance. In order to comprehend the concept of fractions, students must have an established understanding of fractional properties. Trivena et al. (2017) conducted a study on misconceptions about addition and subtraction of fractions among primary school students to determine the level of fraction addition and subtraction mastery among primary school students. Students' understanding of addition and subtraction was dominated by misconceptions, indicating a limited comprehension of the concepts, according to the findings. This is consistent with the research conducted by Pulungan and Suhendra (2019), who investigated misconceptions and errors involving fractions; based on the study's findings, it was discovered that some elementary

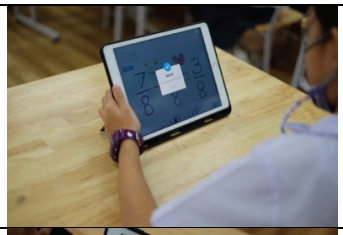
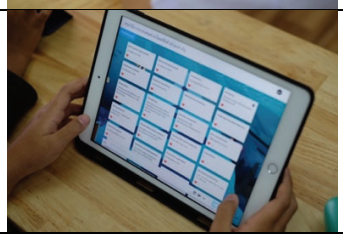
school pupils continue to have misconceptions regarding the concept of fractions. Various categories of errors are caused by these misconceptions when solving fraction problems. As a result of the student's misunderstanding of the actual concept of fractions, these misconceptions appear. The study emphasizes the importance of addressing misconceptions when teaching fractions to enhance students' understanding.

3. An Example of Teaching Mathematics with Blended learning Integrated Simulation on Fractions

In this section, the researchers intend to show the application of technologies in the mathematics classroom in an effort to enhance students' conceptual comprehension and foster positive attitudes towards utilizing technology for the purpose of learning mathematics. The researchers employed the Problem-based learning (PBL) approach as a pedagogical tool for delivering instruction in the present study. Furthermore, the present study also employed a blended learning approach that incorporated both hands-on learning materials and computer simulations. This pedagogical strategy aimed to enhance students' comprehension of the subject matter by facilitating their visualization of the concepts covered during class sessions. In particular, learners consistently regarded this instructional method as an essential part in their acquisition of fractional concepts. (See Table 1)

Table 1. *An Example of Teaching Mathematics with Blended Learning Integrate Simulation on Fraction*

Components	Learning materials	Description of learning process	Examples of learning activity
1.Identify the problem	Video	Teachers present problems to students using familiar everyday situations.	
2.Brainstorm possible solutions	Hands-on	Students used real materials and predicted answers through learning materials.	
3.Research the problem	PhET Simulation	The students search the problem to learn more about it using PhET.	
4.Develop a solution	PhET Simulation	The students doing another problem using PhET.	

Components	Learning materials	Description of learning process	Examples of learning activity
5.Present the solution	Nearpod	The students present their solution to the class	
6.Reflect on the learning	Nearpod	The students apply their knowledge and reflect on the learning process	

4. Methodology

4.1 Participants

The participants in this study consisted of 25 primary students who are studying in the tenth grade, ranging in age from 9 to 10 years old, from a local public school located in the Northeastern part of Thailand. A majority of the students in the class, specifically 64%, demonstrated misconceptions regarding the concepts of addition and subtraction when applied to fractions. The students had already completed a unit on fractional concepts and were afterwards instructed on the operations of addition and subtraction using fractions. Furthermore, the participants possessed the capacity and had experience in utilizing technology for educational purposes on a consistent basis within the classroom setting prior to their involvement in this research.

4.2 Research Instruments

In this study, there are two research instruments as measuring tools of conceptual understanding and attitude toward using technology to learn mathematics. The first tool is a conceptual test involving the conception of addition and subtraction fractions. The test is designed with open-ended questions to measure the ability to understand the topic. It consists of 16 test items converting the concept of addition and subtraction fractions. It has four concepts. There is addition with the same denominator (4 items), addition with a different denominator (4 items), subtraction with the same denominator (4 items), and subtraction with a different denominator (4 items). The second tool is an attitude to learning mathematics with a technology questionnaire. It is a 5-point Likert-scale questionnaire to investigate the student attitude. It consists of 20 items covering mathematics confidence (MC) (4 items), confidence with technology (TC) (4 items), attitude towards the use of technology for learning mathematics (MT) (4 items), affective engagement (AE) (4 items) and behavioral engagement (BE) (4 items). Cronbach's alpha values indicate the following subscale reliability for MC, MT, TC, BE, and AE are 0.87, 0.89, 0.79, 0.72, and 0.65, respectively. The questionnaire was obtained from Pierce et al. (2007).

4.3 Data Collection and Analysis

Students took 30 minutes to complete a pre-test on fraction addition and subtraction. Then, spend another 20 minutes completing a questionnaire about pre-learning mathematics. After completing a pre-test, students received a simulation-based integrated learning arrangement. During data collection, students must discover solutions through PhET simulation, showcase

how to solve problems with Nearpod and reflect on each other. The teacher explains how to use the simulation and the Nearpod application and how to find answers and share them with the class through discussion. The students received a post-test and a questionnaire. (See Figure 1)

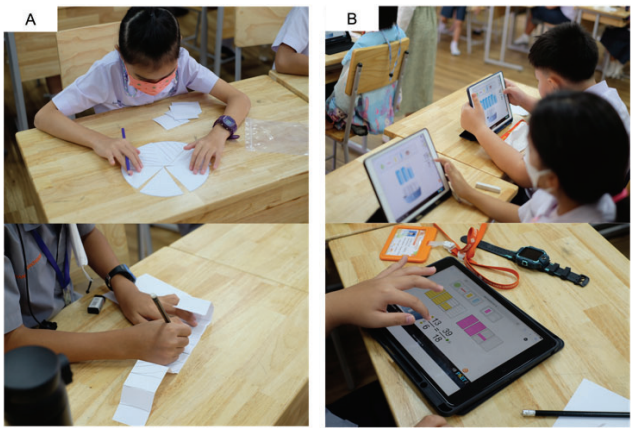


Figure 1. Examples of teaching materials: (A) is hands-on material, (B) is interactive PhET simulation.

The statistical data techniques selected for analyzing students' conception and attitude toward using technology for learning mathematics was Wilcoxon matched pairs signed-ranks test in SPSS 22.0.

4.4 Learning Materials

In the part of the learning activity, technology materials that support the learning process are interactive PhET simulation and interactive presentation from the Nearpod application. Students could also use all applications on their mobile devices. First, the simulation can easily visualize fractional transformations and increase understanding of fraction content meaning of fractions and comparing fractions as well. Moreover, it can change numbers immediately. Whether it's the numerator or the denominator, the picture will also change. This is good for students who want to use their understanding more. Second, the Nearpod application was an interactive classroom tool that enabled teachers to create engaging learning experiences by providing interactive presentations, collaboration, and real-time assessment tools into one integrated solution. Students joined writing solutions on fractions through the Nearpod application. Then, students shared each of the students' writing solutions on fractions with the rest of the class and discussed together along with a summary of mathematical concepts via a collaborative board as show in Figure 2.

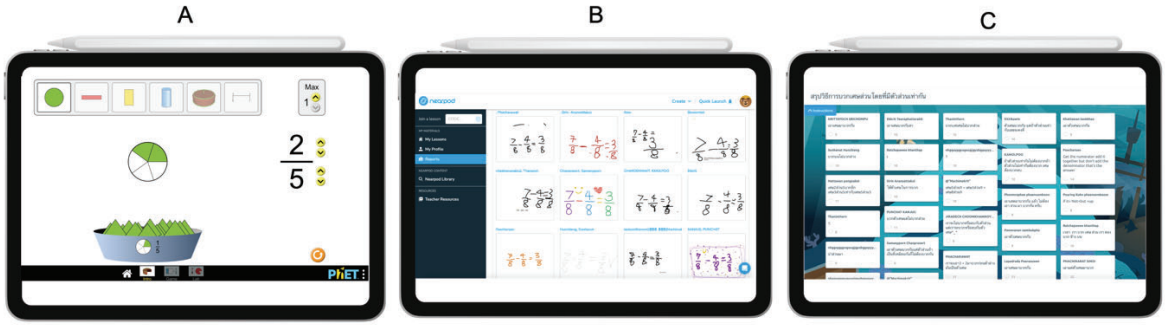


Figure 2. Examples of teaching materials: (A) is PhET simulation, (B) and (C) are Nearpod applications show students' solution and discussion about the answer.

5. Result and Discussion

5.1 Student's Conceptual Understanding in Addition and Subtraction of Fraction

The present study employed nonparametric statistics analysis, specifically the Wilcoxon signed-ranks test, to examine the difference between pre-test and post-test conceptual understanding scores. The results showed a significant increase in students' post-test scores for conceptual understanding of addition and subtraction of fraction concepts compared to their pre-test scores (Z=-4.385, p<.05) as shown in Table 2.

Table 2. *Statistics Of Wilcoxon Matched Pairs Signed-Ranks Test for Students' Conceptual Understanding Scores*

		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig.(2-tails)
Post-Pre	Negative Ranks	0[a]	0	0		
	Positive Ranks	25[b]	13	325	-4.385	<.001*
	Equal	0[c]	-			

* p= <.05

The quantitative result indicates the post-test score of students' conceptual understanding of addition and subtraction fractions was significantly higher than the pre-test score. This finding revealed that the conceptual understanding of students who learn with blended learning with PhET simulation is better after learning. The results related to Arifin et al. (2022) studied the effectiveness of using PhET simulation in primary school students' mathematical understanding of fractions. The results showed that using simulation significantly improved students' mathematical understanding of fractions.

5.2 Student's Attitude toward Using Technology for Learning Mathematics

The Wilcoxon signed-rank test analysis found that there were significant differences between the pretest and post-test for attitude to learning mathematics with technology is mathematics confidence (MC) (Z = -3.733, p < .001), attitude towards the use of technology for learning mathematics (MT) (Z = -4.121, p < .001), confidence with technology (TC) (Z = -3.907, p < .001), affective engagement (AE) (Z = -3.856, p < .001) and behavioral engagement (BE) (Z = -3.805, p < .001) as shown in Table 3

Table 3. *Statistics of Wilcoxon matched pairs signed-ranks test for attitude to learning*

		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig.(2-tails)
MC	Negative Ranks	3[a]	5.17	15.5		
	Positive Ranks	20[b]	13.03	260.5	-3.733	<.001*
	Equal	2[c]				
MT	Negative Ranks	1[d]	6	6		
	Positive Ranks	23[e]	12.78	294	-4.121	<.001*
	Equal	1[f]				
TC	Negative Ranks	2[g]	6.75	13.5		
	Positive Ranks	22[h]	13.02	286.5	-3.907	<.001*
	Equal	1[i]				

		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig.(2-tails)
AE	Negative Ranks	2[j]	4	8		
	Positive Ranks	20[k]	12.25	245	-3.856	<.001*
	Equal	3[l]				
BE	Negative Ranks	3[m]	5.67			
	Positive Ranks	21[n]	13.48		-3.805	<.001*
	Equal	1[o]				

* p= <.05

From the study, the overall outcome was students' attitude toward using technology for learning mathematics. There are good results from using technology in mathematics classrooms, as simulations keep students excited, interested. The students liked it and gave it a lot of attention. As well as showing how to do the problem, students can write on iPads. Easy to write, edit the answer, present students' ideas, type, and write along with seeing classmates' answers for talk and discussion. In the meantime, Emata (2023) examined the relationship between math self-efficacy, technology attitude, and attitudes toward mathematics among students. The study found a moderate level of math self-efficacy and attitudes towards math among the students, while the level of technology attitude is high. So, from the study's results, technology should be adapted to teaching and learning.

5.3 Student's Interview on the Attitude toward Using Technology for Learning Mathematics

This study found that students' attitudes toward using technology for learning mathematics. The researchers chose to explain each of the five types of explanations with an example from a student.

5.3.1 Mathematics Confidence: Student A said:
"I'm not afraid to make a math problem. Because it's easy to edit from the iPad without a pencil and eraser."

5.3.2 Attitude Towards Use of Technology for Learning Mathematics: Student B said:
"I love to use apps for math. because normal learning is boring, I like math, but I don't like writing numbers and answers on books. I like math games and anything else that can't just be learned from books"

5.3.3 Confidence with Technology: Student C said:
"I like to use iPad because it's very easy to use, easy to write, easy to click. I want to use iPad in every class."

5.3.4 Affective Engagement: Student D said:
"I'm so excited to use iPad to learn math because I love to see and share my solution with my classmates through the app."

5.3.5 Behavioral Engagement: Student E said:
"I am very focused when studying math. Because I have to keep up with the teacher, I wish I had more time to do the problem. because the teacher gives little timer"

That means students are not worried about showing how to do or responding to answers through technology. Because technology makes it easy to write and answer, students

do not enjoy learning solely from books. They enjoy using technology to learn, need to talk to their classmates about the answers they have received, and are determined to learn, making efforts to listen and focus on their studies to keep up with both the teacher and their classmates in the classroom. This qualitative study showed students' attitudes to learning mathematics with technology. The result indicated that many students described an attitude related to mathematics, confidence, attitude towards the use of technology for learning mathematics, confidence in technology, affective engagement, and behavioral engagement.

6. Conclusion and Limitation

Based on the research findings, it can be concluded that blended learning with technology can better resolve misconceptions about addition and subtraction of fractions. Furthermore, PhET simulations can help students visualize and increase their comprehension. Additionally, students interact through the Nearpod application that could exchange their ideas with classmates immediately. Moreover, students have positive attitude to learning mathematics with technology. It's implied that teaching mathematics with blended learning toward technologies had an effect on students' conceptual understanding and attitude toward technology in fraction concept in mathematics classroom.

Based on the results of the research, technology plays an essential role in the correction of mathematical misconception. Technologies that facilitate learning, such as PhET and Nearpod, are widely available and compatible with various devices, including smartphones, tablets, and laptops. These technologies have the potential to enhance student achievement by improving teaching and learning processes. Conceptual understanding can be attained through all six stages, with the most pronounced expression occurring throughout the stage of Brainstorming possible solutions. This stage involves the utilization of physical materials, including the stage of Researching the problem and developing a solution, where the use of PhET is employed. Consequently, this process facilitates the formation of precise concepts. One potential limitation of this study is its reliance on a single sample, hence resulting in a limited sample size. Consequently, researchers are unable to make comparisons between scores, behaviors, and students' attitudes towards learning in relation to both traditional teaching methods and blended teaching incorporating simulation. The sample utilized in the study did not yield results that can be generalized to the general population. In future investigations, it is recommended that researchers conduct trials on a substantial cohort of students.

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