Mathematics Learning Design using Phet Interactive Simulation to Support Students Mathematical Understanding

Slamet Arifin*, Febby Fajar Nugraha, Pajar Anugerah Prasetyo

Universitas Kuningan, Kuningan, Indonesia

{slamet.arifin@uniku.ac.id}

Abstract. Technology has a significant role during the period of Pandemic Covid-19 to support students learning. The purpose of this study was to enhance 3rd-grade primary school students' mathematical understanding using PhET Interactive Simulation in fractions learning. The quasi-experiment research design was administered in order to answer the research question. The participants of this study were 48 3rd grade students in Kuningan, West Java. The data were collected through tests of students' mathematical understanding of fractions and classroom observation. The result of this study proves that PhET Interactive Simulation was significantly improved students' mathematical understanding of Fractions.

Keywords: Mathematics Learning; PhET Interactive Simulation; Covid-19 Education

1 Introduction

The spread of the 2019 Corona Dieses Virus (Covid-19) has affected education systems around the world. In response to these conditions, most schools have implemented physical distancing (social distancing) and implemented teaching and learning practices through distance learning (PJJ) to prevent the spread of transmission to students [1]. The Indonesian government through the Ministry of Education and Culture (Kemdikbud) has decided to implement the PJJ policy or in other terms known as distance learning/remote learning since March 24, 2020 (Kemdikbud, 2020). This condition makes students in Indonesia experience the same thing as in other countries, where they are taught by teachers through online media during the period of the spread of Covid-19 [2].

As a consequence of the implementation of PJJ, today we are witnessing students using their laptops or smartphones to access online learning content from home as a consequence of the spread of the 2019 Corona Dieses Virus (Covid-19), this also occurs in the practice of learning mathematics. However, there is debate among experts in the field of mathematics education about the most optimal way to teach mathematics. On the one hand, some experts argue that teaching mathematics should include a clear explanation from the teacher about the procedures followed by practice and correction [3]. On the other hand, those who argue that good mathematics learning occurs when students learn to complete mathematical tasks and understand mathematical concepts independently through reasoning, investigation, and proof [4] [5]. The debate then raises the question " PJJ will be optimal for teaching mathematics to students?"

UNISET 2021, December 02, Kuningan, Indonesia

DOI 10.4108/eai.2-12-2021.2320193

Research evidence shows that online-based mathematics learning is much more problematic than other subjects [6]. Mathematics which tends to be abstract requires teachers to be able to provide a strong conceptual and procedural understanding and develop reasoning abilities for students in learning mathematics. The reality on the ground in the context of mathematics education in Indonesia during the pandemic shows that mathematics learning is still dominated by learning activities that are rigid and less interactive [7]. This may happen considering that during the pandemic, time, location and distance are a big problem at this time [8]. It should be realized that the unpreparedness of teachers and students towards online learning is also a problem. The shift from conventional learning systems to online systems is very sudden, without proper preparation. But all of this must be carried out so that the learning process can run smoothly and students actively participate even in the conditions of the Covid-19 pandemic. The application of distance learning with online media raises various debates related to accessibility, affordability, flexibility, and learning pedagogy [9]. Distance learning makes it difficult for teachers to provide explanations and provide the desired tasks to meet student learning needs [5]. The results also show that students who study online are more anxious than students who study in traditional classes on learning materials that are considered complex [10]. High mathematics anxiety affects student learning achievement or low mathematics learning achievement [11]. Satisfaction during online learning or distance learning is considered an important factor for student success [12].

Based on the description of the problems described in the previous paragraph, this study offers a solution by using PhET interactive simulation to improve students' mathematical understanding and reasoning skills in learning mathematics.

2 Method

2.1. Research Design

A quasi-experimental study was conducted to answer the research questions. There were two research groups of 3rd-Grade students participating in this research. One group was conducting mathematics learning using PhET Interactive Simulation, and the other one conducting mathematics learning through normal teaching. In particular, the research design presented in Table 1.

Table 1. Quasi Experiment Control Group Pre-Test and Post-Test Design

Group	**Pre-test**	**Treatment**	**Poat-test**
Experiment	O_1	PhET	O_2
Control	O_1	Powerpoint	O_2

2.2. Participants

Two groups (each 24) of fourth-grade students (9 to 10 years old), who were learning fractions in the school participated in this quasi-experimental study. The two classes of the participants were located in an elementary school in Kuningan, Indonesia

2.3. Intervention

The instructional design in the experimental group was delivered by the first author while the students in the control group delivered by the teacher. The experimental group was conducting mathematics learning using PhET interactive simulation, and the control group was conducting mathematics using PowerPoint. The treatment in each group was conducted in three time series of a mathematics lesson, 3 x 150 minutes. The lesson plan was developed to deliver mathematics learning on the topic of fractions.

2.4. Data Analysis

Statistical analysis of the quantitative data was conducted using *independent sample t-test*. The prerequisite tests consist of normality, homogeneity, and balance tests that were conducted before the *independent sample t-test*. The normality test was conducted to determine whether the sample under study is normally distributed or not. The normality test in this research used the Kolmogorov Smirnov. The homogeneity test was conducted to determine whether variants of the populations are homogenous or not. All the statistical tests were conducted through a statistical software program named IBM SPSS 26.

3 Result

4.1. Descriptive Statistic Result

The first phase of the data analysis process was conducted using the descriptive analysis to draw the data collected from the pre-test and post-test of control and experimental groups. The descriptive statistic result of pre-test and post-test of control and experimental groups are presented in Table 2.

Table 2. Descriptive Analysis of Control and Experiment Groups

Group	Statistic	Score Pre-Test	Post-Test	N
Control	Mean	33.95	66.87	24
	Std. Deviation	9.08	10.91	
	Minimum	10.00	35.00	
	Maximum	50.00	90.00	
Experiment	Mean	35.20	76.04	24
	Std. Deviation	7.50	13.10	
	Minimum	20.00	40.00	
	Maximum	50.00	100.00	

The data presented in Table 2 shows the descriptive statistic score of the pre-test of SMU score on the control group that conducted learning through PowerPoint (M = 33.95, SD=9.08, Min = 10.00, Max = 55.00). Following this result, the post-test of SMU on the control group students shows (M = 66.87, SD=10.91, Min = 35.00, Max = 90.00). On the other hand, according to the data presented in Table 2, the experimental group of students who were conducting learning through PhET Interactive Simulation show that the pre-test score of SMU (M = 35.20, SD=7.50, Min=20.00, Max=50.00). Moreover, the post-test score shows (M=76.04, SD=13.10, Min=40, Max=100).

4.2. Normality and Homogeneity test

The normality and homogeneity test was conducted as a prerequisite test to determine the type of hypothetical test conducted through the parametric or non-parametric test. The normality test of the post-test score is presented in Table 3.

Table 3. Normality Test of Post-Test Score

Variable	Group	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
SMU	Powerpoint	.140	24	.200*
	PhET Interactive Simulation	.135	24	.200*

According to the normality test result of the post-test score of SMU presented in Table 3, the normality test for SMU of students that participating mathematics learning using PowerPoint indicates that (D(24 = 0.200, P > 0.05), therefore it can be concluded that the SMU score of students with PowePoint is normally distributed. Moreover, the result of the normality test for students who participated in mathematics learning using *PhET interactive simulation* indicated that (D(24 = 0.200, P > 0.05), therefore it can be concluded that the SMU score of students with *PhET interactive simulation* is normally distributed.

After the prerequisite test conducted through the normality test, then the homogeneity test of the variance was conducted to determine whether the data were homogenous or heterogenous. The result of the homogeneity test is presented in Table 4.

Table 4. Test of Homogeneity of Variance

Variable	Levene Statistic	df1	df2	Sig.
SMU	.519	1	46	.475

As the data presented in Table 4, the post-test score of SMU shows (P = 0.475, > 0.05). Therefore, the result of the homogeneity test presented in Table 4 indicates that both the post-test score of SMU is homogeny. Following this result of the normality and homogeneity test, then the hypothetical test was conducted through a parametric test using the *Independent sample t-test*.

4.3. Independent Sample T-Test

The hypothesis test was conducted through an independent sample t-test using. The use of independent sample t-test in hypothesis testing was underlined by the normality and homogeneity test of the post-test score of students' fractions understanding. The result of the test are presented in Table 4.

Table 4. Independent Sample T-Test of Post-Test Score

Variable	Levene's Test for Equality of Variance				
	F	Sig.	T	df	Sig. (2-tailed)
Post-Test SMU	.519	.475	-2.633	46	.011

According to the data presented in Table 4, the result of the *independent sample t-test* shows that (t(48)= -2.63, P < 0.05). Therefore, it proves that PhET Interactive Simulation was significantly improved students' mathematical understanding of Fractions.

4 Discussion

Mathematics teaching and learning in the pandemic period was challenging for the teachers to support students' understanding of mathematics concepts. Therefore, the use of digital technology have an important role to support teaching and learning practice in school. Educational technologies that afford students a virtual environment have the potential to scaffold and support teaching and learning [13].

This research provides evidence of the implementation of alternative media name *PhET Interactive Simulation* to help students understand mathematics concepts, especially in understanding fractions. The findings of our study proved that *PhET Interactive Simulation* has significantly enhanced students' mathematical understanding of fractions. This is in accordance with the previous research conducted by [14] proved that students that learn mathematics using *PhET Interactive Simulation* significantly enhance students' performance. The use of interactive simulation also could give students more deep conceptual understanding.

5 Conclusion

According to the findings and the discussion mentioned earlier, there are some conclusions related to this study. The PhET interactive simulation was proved that have a significant effect on the SMU on learning fraction. The PhET interactive simulation media was influential in developing SMU. Therefore, the PhET interactive simulation is decent to implement by mathematics educators as an alternative learning media in teaching mathematics.

References

[1] H. Song, J. Wu, and T. Zhi, "Online Teaching for Elementary and Secondary Schools During COVID-19," *ECNU Rev. Educ.*, vol. 3, no. 4, pp. 745–754, 2020, doi: 10.1177/2096531120930021.

[2] Mailizar, A. Almanthari, S. Maulina, and S. Bruce, "Secondary school mathematics teachers' views on e-learning implementation barriers during the COVID-19 pandemic: The case of Indonesia," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 16, no. 7, 2020, doi: 10.29333/EJMSTE/8240.

[3] P. A. Kirschner, J. Sweller, and R. E. Clark, "Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching," *Educ. Psychol.*, vol. 41, no. 2, pp. 75–86, 2006, doi: 10.1207/s15326985ep4102_1.

[4] D. L. Schwartz and T. Martin, "Inventing to prepare for future learning: The hidden efficiency of encouraging original student production in statistics instruction," *Cogn. Instr.*, vol. 22, no. 2, pp. 129–184, 2004, doi: 10.1207/s1532690xci2202_1.

[5] P. Sullivan *et al.*, "Threats and opportunities in remote learning of mathematics: implication for the return to the classroom," *Math. Educ. Res. J.*, vol. 32, no. 3, pp. 551–559, 2020, doi: 10.1007/s13394-020-00339-6.

[6] G. G. Smith and D. Ferguson, “Student attrition in mathematics e-learning,” *Australas. J. Educ. Technol.*, vol. 21, no. 3, pp. 323–334, 2005, doi: 10.14742/ajet.1323.

[7] T. Wahyuningrum, A.S&Latifah, “Investigating mathematical conversation in remote learning of mathematics during the covid-19 pandemic,” *J. Ris. Pendidik. Mat.*, vol. 7, no. 2, pp. 148–162, 2020, [Online]. Available: https://journal.uny.ac.id/index.php/jrpm/article/view/34841/14993.

[8] J. W. Kusuma and H. Hamidah, “Perbandingan Hasil Belajar Matematika Dengan Penggunaan Platform Whatsapp Group Dan Webinar Zoom Dalam Pembelajaran Jarak Jauh Pada Masa Pandemik Covid 19,” *JIPMat*, vol. 5, no. 1, 2020, doi: 10.26877/jipmat.v5i1.5942.

[9] S. Dhawan, “Online Learning: A Panacea in the Time of COVID-19 Crisis,” *J. Educ. Technol. Syst.*, vol. 49, no. 1, pp. 5–22, 2020, doi: 10.1177/0047239520934018.

[10] T. A. DeVaney, “Anxiety and attitude of graduate students in On-Campus vs. online statistics courses,” *J. Stat. Educ.*, vol. 18, no. 1, pp. 1–15, 2010, doi: 10.1080/10691898.2010.11889472.

[11] D. P. Wardani, S. Prabawanto, and T. Herman, “Analyze the correlation of hafiz qur ’ an and yaumiah worship toward the level of math anxiety,” *Int. Conf. Math. Sci. Educ. Promot. 21st Century Ski. Through Math. Sci. Educ.*, vol. 3, pp. 848–852, 2018.

[12] D. U. Bolliger and O. Wasilik, “Factors influencing faculty satisfaction with online teaching and learning in higher education,” *Distance Educ.*, vol. 30, no. 1, pp. 103–116, 2009, doi: 10.1080/01587910902845949.

[13] K. W. McElhaney, H. Y. Chang, J. L. Chiu, and M. C. Linn, “Evidence for effective uses of dynamic visualisations in science curriculum materials,” *Stud. Sci. Educ.*, vol. 51, no. 1, pp. 49–85, 2015, doi: 10.1080/03057267.2014.984506.

[14] K. Ndihokubwayo, J. Uwamahoro, and I. Ndayambaje, “Effectiveness of PhET Simulations and YouTube Videos to Improve the Learning of Optics in Rwandan Secondary Schools,” *African J. Res. Math. Sci. Technol. Educ.*, vol. 0, no. 0, pp. 1–13, 2020, doi: 10.1080/18117295.2020.1818042.