The influence of the online PhET simulation-assisted using direct instruction on student’s conceptual understanding of parabolic motion

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Abstract. This study aimed to investigate the effect of the online PhET simulation-assisted using the direct instruction on students' conceptual understanding of the parabolic motion. It was quasi-experimental research with pretest-posttest control group design. The research subjects were 10th grade students, consisting of 20 students for each experimental and control groups. The data were collected using a concept understanding test. The research data were analyzed quantitatively by using descriptive and inferential statistics. The results show that the average score of the experimental class was higher than the control class. The hypothesis was tested using Mann-Whitney (U-Test) with a significance level of = 0.05. Based on data analysis, it can be concluded that there was a significant effect of online PhET simulation assisted learning model on students' concept understanding on parabolic motion.

1. Introduction

During the pandemic era, the use of technology plays a crucial role in the realm of education. Its utilization, especially in online classes, requires creativity and instructional considerations [1]. Technology application that has been widely used to support the learning process is simulations [2]. One of the interactive simulation platforms that is frequently used in physics learning is Physics Education Technology (PhET) [3]. PhET was developed by the University of Colorado at Boulder, United States to provide various simulations to explain concepts and theories in interactive and interesting ways that can be run from websites using standard web browsers [4][5]. Moreover, the users are also able to download and install the website and use it for offline learning [6].

Virtual laboratory-based is effective in physics learning for both the teachers and students [7][8]. Its application can improve students’ interest in physics [9][10], which is heavily correlated with conceptual understanding [11]. Using simulation in learning activities can provide learning experiences while playing [12]. The simulation helps students examine a physical phenomenon or event through an interesting illustration [13][14][15]. Further, the previous study indicated that the use of PhET simulation in direct instruction can increase students' creativity [16].

Direct instruction is a teacher center learning [6]. This model is suggested for learning during the pandemic situation in Indonesia since students are not familiar with the self-study type of learning.
from their respective houses [17]. Accordingly, teachers’ roles in learning become dominant in creating interesting learning activities for students [6]. Teachers should not solely focus only on the topic explanations, but also on the knowledge and skill demonstration thus teachers are required to use a variety of learning media [18].

Students' learning experiences in the direct learning model train students to think, apply the skills they have just acquired, and build their own understanding so that the learning process becomes active [18]. There are five important stages in direct learning, namely the orientation, presentation or demonstration, structured exercises, guided exercises, and independent exercises. The application of direct instruction can encourage students to think and apply the acquired knowledge [18]. In addition, it also can increase students’ learning experiences, foster scientific attitudes and teamwork [19]. However, due to the unprecedented situation in the couple years, learning activities have changed from face-to-face to totally virtual learning. Despite the challenging condition, learning processes can still be conducted because of the technology [20]. Some benefits of online learning with the utilization of effective multimedia are improving the quality and the range of quality of education and training, and reducing the cost of education and training [21]. Since the learning activity is conducted through a web network, it can accommodate many participants from different locations and expertise [22].

Students who have concept understanding on a taught topic have the ability to explain it in their words and to apply it in a real-life situation [23]. Conceptual understanding in physics is crucial due to the intercorrelation among the concepts and theories. Students who do not understand a concept will encounter difficulty to understand the next material [24]. One of the physics topics that is challenging for students is parabolic motion [25]. It is complex because students require explanations in the form of graphic images, vectors and real examples in everyday life [26]. Some misconceptions about parabolic motion were about the complex nature of motion. Many students still have misconceptions on the differences between the main principles of kinematics, including position, velocity, acceleration and time [27]. In addition, the use of graphic interpretation, representation, equations and also combining two-dimensional motion in this topic makes it a difficult topic [28]. Students have particular difficulty in analyzing the components of velocity and acceleration on the x-axis and y-axis and making two graphs of the relationship between velocity and time or v-t graphs [29][30]. It was frequently found on students’ mistakes during problem solving [31].

Previous researchers mostly conducted direct learning using PhET simulation in face-to-face mode learning. It is rare to find a study that has investigated the impact of PhET simulation integrated in direct instruction virtually. On that account, this study aims to measure the effect of a direct learning model assisted by PhET simulations in virtual learning on students' conceptual understanding in parabolic motion.

2. Methods
This research was a quasi-experiment with pretest-posttest control group design. It was conducted in one of the public schools in the Sigi Regency, Central Sulawesi. A total of 40 students were involved in this study, with 20 students for each experimental and control group. The samples were chosen using simple random sampling by lottery. Students in the experimental class were taught using a direct learning model assisted by online PhET simulation while the control class was only taught using the direct instruction. Both groups went through the same stages of learning, including the material delivering, peer discussion, and presenting and feedback session stage. The difference was on the method used on the material delivering stage. In the control group the teacher provided material in the form of written resources. By doing so, students were able to interpret and provide conclusions from the material they had read. Meanwhile, in the experimental group the teacher guided the students to experiment with parabolic motion using PhET simulation after the material explanation.

Data were collected using a concept understanding test. It was an essay test consisting of 5 questions. The test was used to measure students’ understanding of physics concepts both before and after the implementation of the online PhET simulation-assisted using direct instruction. Each question represented one indicator, namely translation indicator for question number 1 and 3, interpretation of
question for question number 2, and extrapolation for numbers 4 and 5. These indicators were adopted from a study of Wuryanti et al [23]. The data were analyzed quantitatively using descriptive and inferential statistics. Descriptive statistics were used to describe the achievement of each variable, while inferential statistics were for the hypothesis test [32]. The alternative hypothesis of this study was that the use of direct instruction with PhET simulation virtually has a significant effect on students’ conceptual understanding in parabolic motion.

3. Results and Discussion

Based on the descriptive data, there was a difference in conceptual understanding between students in the control and the experimental groups. The pretest results showed that the control class got a higher average score than the experimental class. Meanwhile, the average score of the posttest indicated that the experiment outperformed the control class. Detailed data were presented in Table 1.

| Description | Pretest | Posttest |
|-------------|---------|----------|
| Sample (n)  | Control | Experimental | Control | Experimental |
| Minimum value | 45 | 40 | 45 | 50 |
| Maximum value | 80 | 80 | 85 | 95 |
| Average     | 60 | 55 | 64 | 76 |

The results of indicator analysis for each question between both groups can be seen in Figure 1.

Data presented in Table 1 and Figure 1 show that there are differences between the control and treatment group. It is owing to the phases of learning activities that encouraged students to be more active and involved in learning although all the activities were constructed online. The demonstration using the PhET simulation allowed to reduce the level of variance in the study of understanding and to develop accurate conceptual understanding [33]. Moreover, online PhET simulation can improve students’ thinking skills [4]. Students in the treatment group outdid the control group because the use of simulation helped them to stay focused on the topic delivering process [34]. It is evident that PhET simulation gives a positive effect in learning [35], in either offline or online mode of learning. Without the use of PhET simulation, students in the control group lacked interest in learning. However, since
direct instruction consists of a discussion after the stage of delivering material lessons, it was able to increase students’ interest. A group discussion was also used to support the implementation of the learning process [36]. The posttest score of the control group also improved compared to the pretest. It shows that the direct instruction also increased students’ learning outcome, although as not as effective as when it was assisted by PhET simulation.

Understanding the concept of parabolic motion in the indicator of translation is quite good. It is shown by the score for the translation aspect which has the highest score compared to the other indicators. Students could describe graphs and pictures verbally correctly. It was in accordance with the study of Jelatu and Kurnila [36] who found that most of their research subjects were in the medium category which meant that they had the ability to translate from verbal to visual forms yet had not done perfectly. Further, the finding was in contrast with the result of Usman and Hussaini’s study who discovered that many students still failed to translate mathematical problems which denoted that the translation aspect among students was generally poor.

Regarding the interpretation aspect, most students were good at interpreting questions in the form of pictures into verbal form. Although some had not interpreted the answers completely or according to the concept. It was in line with the study of Amin et al [37] who stated that some students were not able to identify physical quantity variables and resulting in incomplete answers. Meanwhile, the result for the extrapolation aspect showed that most students were unable to describe the correct answers according to the concept. It was identified through the students’ mistakes in determining the trajectory of the elevation angle. Most of the students could not predict symbols or graph slope patterns on questions [38]. These results contradict the research conducted by Susac et al [39] who found that most students have a good understanding of the extrapolation aspect. Students in their study successfully predicted the graphs from the mathematical form on kinematics material.

Due to the small sample study, the Mann-Whitney U-Test was used for the hypothesis test with a significance level of 0.05 criteria [40]. The results of hypothesis testing can be seen in Table 2.

| Class       | U_{count} | U_{table} (α = 0.05) | Decision |
|-------------|-----------|----------------------|----------|
| Experiment  | 94.5      | 114                  | H₁ accepted |
| Control     |           |                      |          |

Based on Table 2, the value of U_{count} was 94.5, which was higher than the value of U_{table} of 114. The value of U_{count} was outside the reception area of H₀ which means that the H₀ was rejected and H₁ was accepted. It indicates that there was an increase in understanding of concepts in students who learned with direct instruction assisted by the online PhET simulation. This method has proven to be quite effective to foster students’ interest and enthusiasm in learning [41]. In addition, this method enables students to have the opportunity to discuss and express their opinions related to questions in the worksheet based on their understanding using PhET simulations. Students can conclude the results of their discussions and can better understand and explain the concepts of physics that they have learned.

4. Conclusion
The results indicated that there was an effect of the direct instruction with PhET simulation in online learning on students’ conceptual understanding of parabolic motion. It shows that PhET simulation is beneficial for students’ learning outcome in both online and offline learning. Moreover, the use of PhET simulation is suitable to be integrated with direct instruction since this model allows the students to further discuss and restate the concepts they have learned on their own words through the peer discussion, and presenting and feedback session stage.
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References
[1] Lestiyanawati R 2020 The Strategies and Problems Faced by Indonesian Teachers in Conducting e-learning during COVID-19 Outbreak CLLiENT (Culture, Lit. Linguist. English Teaching) 2 71–82
[2] Whitacre I, Hensberry K, Schellinger J and Findley K 2019 Variations on play with interactive computer simulations: balancing competing priorities Int. J. Math. Educ. Sci. Technol. 50 665–81
[3] Rahayu C D and Sartika S B 2020 Students Learning Motivation and Concepts Understanding of Science through the Use of PhET Interactive Simulations SEJ (Science Educ. Journal) 4 63–76
[4] Sulisworo D, Ramadoan N, Ardianti S and Widodo 2019 Promoting PhET Simulation on Online Learning to Enhance Critical Thinking Skills 5Th Int. Conf. Educ. Res. Pract. 2019 Educ. Digit. Soc. Integr. Humanist. Sci. Values 58–63
[5] Batuyong C T and Antonio V V 2018 Exploring the Effect of PhET® Interactive Simulation-Based Activities on Students’ Performance and Learning Experiences in Electromagnetism Asia Pacific J. Multidiscip. Res. 6 121–31
[6] Buchori A, Setyosari P, Dasna I W, Ulfıa S, Degeng I N S and Sa’dijah C 2017 Effectiveness of Direct Instruction Learning Strategy Assisted by Mobile Augmented Reality and Achievement Motivation on Students Cognitive Learning Results Asian Soc. Sci. 13 137
[7] Habibbulloh M 2019 Effectiveness Of the Guided Discovery Model Based Virtual Lab Phet Toward Mastery Students’ Concept On Topic Photoelectric Effect Sci. Educ. Appl. ...
[8] Faour M A, Ayoubi Z and The Z 2018 The Effect of Using Virtual Laboratory on Grade 10 Students’ Conceptual Understanding and their Attitudes towards Physics J. Educ. Sci. Environ. Heal. 4 54–68
[9] Taibu R, Mataka L and Shekoyan V 2021 Using PhET simulations to improve scientific skills and attitudes of community college students Int. J. Educ. Math. Sci. Technol. 9 353–70
[10] Habibi H, Jumadi J and Mundilarto M 2020 Phet simulation as means to trigger the creative thinking skills of physics concepts Int. J. Emerg. Technol. Learn. 15 166–72
[11] Astutik S and Prahani B K 2018 The Practicality and Effectiveness of Collaborative Creativity Learning (CCL) Model by Using PhET Simulation to Increase Students’ Scientific Creativity Int. J. Instr. 11 409–24
[12] Sarwoto T A, Jatmiko B and ... 2020 Development of online science teaching instrument based on scientific approach using PhET simulation to improve learning outcomes at elementary school ... Int. J. ...
[13] Perdana R, Riwayani R, Jumadi J and Rosana D 2019 Web-Based Simulation on Physics Learning to Enhance Digital Literacy Skill of High School Students JIPF (Jurnal Ilmu Pendidik. Fis.) 4 70
[14] Prima E C, Putri A R and Rustaman N 2018 Learning solar system using PhET simulation to improve students’ understanding and motivation J. Sci. Learn. 1 60
[15] Sari D P, Tjandrakirana T and Kuntjoro S 2018 Applying Science Learning Phet Simulation To Improve Process Skill And Knowledge Aspect Of Junior High School Student JPPS (Jurnal Penelit. Pendidik. Sains) 7 1496
[16] Oktavia F, Muhibbuddin and Mursal 2020 Direct instruction model assisted with PhET and Whatsapp to students’ cognitive and motivation J. Phys. Conf. Ser. 1460
[17] Warju W, Ariyanto S R, Soeryanto S, Hidayatullah R S and Nurtanto M 2020 Practical Learning Innovation: Real Condition Video-Based Direct Instruction Model in Vocational
Education J. Educ. Sci. Technol. 6 79–91
[18] Fayanto S, Misrawati M, Sulisworo D, Istitqoham H F N and Sukariasih L 2019 The Implementation of Multimedia on Physics Learning Based on Direct Instruction Model in The Topic of Light Indones. J. Learn. Educ. Couns. 1 124–32
[19] Polonia B S E and Ravi A 2020 Effect of Direct Instruction Models Toward Students’ Understanding of Physics Formula Berk. Ilm. Pendidik. Fis. 8 133
[20] Bhuana G P and Apriliyanti D L 2021 Teachers’ Encounter of Online Learning: Challenges and Support System J. English Educ. Teach. 5 110–22
[21] Marvin Díaz V, Reche Urbano E and Maldonado Berea G 2013 Advantages and disadvantages of online training Ritu 7 2
[22] Hamid R, Sentyro I and Hasan S 2020 Online learning and its problems in the Covid-19 emergency period Prima Edukasia 8 86–95
[23] Wuryanti S, Hadiana D and Purwati R 2020 Factors affecting the translation, interpretation, and extrapolation abilities in elementary school students’ learning achievement J. Penelit. dan Eval. Pendidik. 24 198–207
[24] Martín Ramos P, Ramos Silva M and Silva P 2017 Smartphones in the teaching of Physics Laws : projectile motion RIED. Rev. Iberoam. Educ. a distanca
[25] Serevina V and Raida R 2021 Improving the Quality of Education in the Covid-19 Era Through the Implementation of Online Learning Resources With Poe2We Model on Parabolic Motion Int. J. Educ. Manag. Innov. 2 13
[26] Kantrowitz R and Neumann M M 2020 The English Galileo and His Vision of Projectile Motion under Air Resistance ed H Engler Int. J. Math. Math. Sci. 2020 9695053
[27] Trudel L 2017 High School Students ‘ Conceptual Understanding Of Parabolic Motion Hawaii University International Conferences
[28] Mufit F 2018 The Study of Misconceptions on Motion’s Concept and Remediate Using Real Experiment Video Analysis
[29] Mambu J Y 2020 Based Physics Game on Android 6 239–50
[30] Pineda C I S 2020 Effectiveness of Validated Teaching-Learning Package in Projectile Motion for Grade 9 Science J. Sci. Sci. Educ. 1 26
[31] Rohadi N, Setiawan I and Swistoro E 2019 Descriptive Qualitative Analysis Based on Physics Mental Model of Students’ Cognit Understanding on the Concepts of Kinematics Particle and Parabolic Motion J. Pembelajaran Fis. 8 121–8
[32] Minium E W, King B M and Bear G 1993 Statistical Reasoning in Psychology and Education
[33] Salame I I and Makki J 2021 Examining the Use of PhET Simulations on Students’ Attitudes and Learning in General Chemistry II Interdiscip. J. Environ. Sci. Educ. 17 e2247
[34] Özcan H, Çetin G and Koştur H İ 2020 The Effect of PhET Simulation-based Instruction on 6th Grade Students’ Achievement Regarding the Concept of Greensea Gas Sci. Educ. Int. 31 348–55
[35] Inayah, Nailil,Masruroh M 2021 PhET Simulation Effectiveness as Laboratory Practices Learning Media to Improve Students ’ Concept Understanding Prism. Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram 9 152–62
[36] Jelatu S and Kurnila V S 2019 Analysis of Translation Understanding from Verbal to Visual on Trigonometry Concept Form. J. Ilm. Pendidik. MIpa 9 191–202
[37] Amin B D, Sahib E P, Harianto Y I, Patandean A J, Herman and Sujiono E H 2020 The interpreting ability on science kinematics graphs of senior high school students in South Sulawesi, Indonesia J. Pendidik. IPA Indones. 9 179–86
[38] Veloo A, Krishnasamy H N and Wan Abdullah W S 2015 Types of student errors in mathematical symbols, graphs and problem-solving Asian Soc. Sci. 11 324–34
[39] Susac A, Bubic A, Martinjak P, Planinic M and Palmovic M 2017 Graphical representations of data improve student understanding of measurement and uncertainty: An eye-tracking study Phys. Rev. Phys. Educ. Res. 13
[40] Corder, Gregory W and Foreman D I 2014 *Nonparametric statistics: A step-by-step approach* (ohn Wiley & Sons)

[41] Haryadi R and Umam A K 2021 Pemanfaatan Simulasi Phet Dalam Mendukung Pembelajaran Fisika Materi Rangkaian Listrik Searah Pada Masa Pandemi *Edufisika J. Pendidik. Fis.* 6 18–21