The effectiveness of the student worksheet with PhET simulation used scaffolding question prompt

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Abstract. This study aimed to identify the effectiveness of student worksheets with PhET simulation using scaffolding question prompt based on student learning outcomes. The experimental design used was one group pretest-posttest design. The samples of the research were 54 students of Elementary School Teacher Education Department who take the Natural Sciences Study 2. The effectiveness of the student worksheet is viewed from the results of student cognitive learning, using learning outcomes tests. The technique of analyzing data used N-gain. Based on the results of the study obtained an increase in learning outcomes reached 0.48, which was categorized in the medium category. The conclusion is that student worksheets with PhET simulation used scaffolding question prompts are effective in improving student learning outcomes.

1. Introduction

Education has an important role in developing the quality of human resources so that they can have strong competitive skills in the workforce [1]. In the 21st-century, physics learning has 4C goals are Communication, Collaboration, Critical Thinking, and Problem Solving, Creativity, and Innovation. Learning physics is not only learning to deal with theory, formulas, and memorization. Studying physics must do something, experience, and solve problems with all aspects related to it [2]. In studying physics cannot directly study the product, but it requires a learning activity that involves students in a problem-solving process or experiment to produce a product [3]. However, based on interviews with students of Elementary School Teacher Education Department students that science learning has only been listening to explanations from teachers and peers, rarely conducting experiments due to unavailability of laboratories and worksheets. One other important problem in learning physics is explaining difficult concepts and difficulties in conducting experiments in the laboratory or the classroom [4]. So that media is needed to overcome these difficulties, one of which is PhET media that simulates material directly (Joseph, 2019; [5]).

PhET simulation is more effective if applied using a supplement or learning support [6]. The use of computer simulations such as PhET media in physics learning can explain in more detail the material concepts of physics and improve students' thinking skills [7] [8]. PhET simulations can support the development of process skills, affective goals, and content learning in an easy, free, and flexible way [9]. The simulation can be accessed for free on the website http://phet.colorado.edu. As stated by Wieman that the PhET simulation has several advantages, which can be used in the classroom, can be
used to conduct experiments, can be arranged according to the questions given, and can be used at home to repeat the material that has been learned in the classroom [7].

The use of PhET in learning should be combined with other teaching materials, so that students’ understanding related to learning materials will be better [10]. Teaching materials play an important role in ensuring the effectiveness of teaching and learning activities [11]. For the goals of physics learning in the 21st century to be achieved, teaching materials are needed by current conditions such as worksheets [12]. Student worksheets are material that is practical, useful, and economical for use in educational activities [13]. Student worksheets allow students to be more active and successful in increasing student participation in the classroom [14]. Teachers use student worksheets for the purpose of supporting learning, promoting active learning, increasing interest in learning science, and valuing [15]. Student worksheets are found to be more successful than teaching using traditional [14]. Student worksheets can improve learning success and make students more active and efficient in learning [16] [17]. As an assessment tool, worksheets can be used by teachers to understand students' prior knowledge, learning outcomes, and the learning process at the same time, they can be used to allow students to monitor the progress of their learning [15].

It is indicated that the way to solve the problem will be indicated by providing the necessary guidance to students with worksheets [14]. Based on the results of the study [18] [19] [20] showed that the PhET assisted worksheets developed could improve student learning outcomes but had not used guidance in the form of questions. Giving questions prompts is one form of scaffolding that can help students learn and develop thinking skills [20]. Scaffolding strategies include feedback, question prompts hints, and expert modeling [21] [22]. Print scaffolding in the form of process worksheets has been proven effective in helping students improve learning performance [23]. Scaffolding can improve their conceptual understanding of physics material [24]. In worksheets, characteristics of questions are important factors [15]. Questions prompts are used as a scaffold to help guide students toward appropriate learning goals, such as focusing student attention and modeling the types of questions students must learn [25]. Also, there has been no research about worksheets in Physics learning that use question prompts scaffolding.

Based on the description described, it might be interesting to integrate PhET simulation with the scaffolding question prompt. PhET simulation is used in electrical material as a learning medium. So, this study aims to identify the effectiveness of student worksheets with PhET simulation used scaffolding question prompts.

2. Method

This type of research was quasi-experimental research. The quasi-experimental goal is to obtain information that is an estimate for information that can be obtained by actual experiments in circumstances that do not allow it to control and or manipulate all variables. The population in this study were students of the Elementary School Teacher Education Department who programed the Natural Sciences Study 2 for the 2018/2019 academic year. The sample of this study consisted of 54 students. The technique in sampling was cluster sampling. The independent variable in this study was the student worksheets with PhET simulation used scaffolding question prompts. The dependent variable in this study was student learning outcomes.

The design used in this research was the one-group pretest-posttest design [26]. Data collection techniques were the test method and questionnaire. The test used to determine student learning outcomes uses essay questions. The questionnaire used to find out the practicality of worksheets by lecturer and students. Practicality considerations can be seen in several aspects, such as ease of use, the time needed in implementation, the attractiveness of services for the interests of students, ease in interpreting, and having similarities in common [26]. The practicality criteria were based on [26]. Data analysis techniques in this study were carried out with the N gain test to determine the effectiveness of student worksheets with PhET simulation used scaffolding questions. The actual gain was the difference between the posttest score and the pretest score [27]. The criteria for the effectiveness of student worksheets were said to be effective if the level of achievement of N-gain was at least in the medium category.
3. Result and discussion
The worksheets given to students are worksheets for Ohm's law, Kirchoff Law, and the Parallel-Series used PhET simulation "Circuit Construction Kit (AC + DC)." In the beginning, worksheets are given introductory questions to guide students to understand the use of PhET simulations. The use of student worksheets on learning was a guided inquiry model for three meetings. Cognitive tests are used to determine student learning outcomes as measured by mastery of learning objectives. The result of the practical test of students worksheet by lecturer and students shows that student worksheet is in practical criteria.

Table 1. Practical test results of student worksheets

| Aspects                        | The value of practicality | Criteria   |
|--------------------------------|----------------------------|------------|
| Ease of use                    | 82%                        | Practical  |
| The time required in the execution | 76%                       | Quite practical |
| The appeal of worksheet on student interest | 70%                        | Quite practical |
| Ease in interpreting           | 80%                        | Practical  |
| Has the same equivalent        | 78%                        | Quite practical |
| Average                        | 77.2%                      | Quite practical |

Based on the results of practical tests conducted by the lecturer and students, the ease of use aspect shows quite practical criteria. This is because student worksheets can be used without special guidance from the lecturer. The ease of use of this worksheet is due to instructions for using an easy-to-understand worksheet and questions that guide students to work on the worksheet well. Worksheets are easier to use because at the beginning of the worksheet there are guiding questions for using PhET simulations, so students are easier to use PhET. Giving guiding questions is one form of scaffolding that can help students learn and develop thinking skills [20]. Using worksheets with PhET Simulation can support content learning in an easy, free, and flexible way [9]. Characteristics of learning media, namely independent, in the sense of providing comfort and completeness of content in such a way that users can use it without the guidance of others. Media can facilitate students to increase understanding and in-depth knowledge [28][29][30].

The time aspect required in the implementation shows that the criteria are quite practical. This shows that student worksheets can save time to explain electrical material because it does not require a long time, such as explaining material without using student worksheets. Worksheets have the benefit of save the time [4].

The ease in interpreting the aspect of the application to the interests of students has quite practical criteria. This is because students first use simulation PhET with worksheets so that they can easily use the simulation. Simulation becomes more effective if using learning or support supplements [6]. The aspect of choosing in interpreting material that chooses practical criteria. This is because student worksheets can be facilitators between lecturers and students. The guidance questions available in the analysis section on the worksheet have been adjusted to the learning objectives to be achieved. Question prompts used as a scaffold to help students toward appropriate learning goals [23].

Aspects have the same equivalent with quite practical criteria. This is due to the material used by the learning objectives that have been formulated so that the material on the student worksheet can represent all the material studied. Worksheets are able to explain the existence of messages and information so that they can accelerate and improve the learning process and attention of students [31]. The assessment results state that worksheets are useful in the learning process, both for lecturers and students. Benefits obtained for lecturers can help in providing the correct explanation of the concept of material to students.

Table 2. Student Achievement Results

|        | Pretest | Posttest | N-Gain | Criteria |
|--------|---------|----------|--------|----------|
|        | 34.54   | 66.07    | 0.48   | Medium   |
Student learning outcomes could be seen in Table 2. From these data, it is known that the average score of student learning outcomes is 66.07, with N gain 0.48. Learning outcomes analysis is used to see the level of success of students in using student worksheets. Worksheets with scaffolding questions using PhET simulation in this study can provide meaningful learning experiences. This is because the student worksheet given in the initial section contains Scaffolding in the form of initial questions, so students understand how to use the PhET electric simulation. Questions are not only given at the beginning of the worksheet but also guidance questions for analyzing the results of the experiment. This question is given as guidance to students to achieve the objectives of the worksheet. Questions are given to build students' knowledge, which decreases until students finally can understand the concept of physics independently [32]. One of the main advantages posed for question prompts is to improve students' metacognition. Each question prompts targets the skills needed to solve the problem [33]. Students read questions that direct their attention to the elements of important problems and encourage them to perform certain tasks [34]. The core of student success is the use of scaffolding, which helps students to participate meaningfully [21]. Many studies have shown that the effectiveness of the questions asked can vary according to individual abilities (e.g., initial knowledge, cognition and metacognition, and problem-solving skills) and different question prompts [11] One possible reason why the criteria for effectiveness are still in the medium category is the use of questions that have not considered the level of students' prior knowledge and problem-solving skills.

PhET as a computer simulation can provide a more meaningful and understandable way for students to learn science concepts [35]. This is because PhET simulations, especially in physics, can specifically describe phenomena in everyday life. The students can obtain the appropriate visual explanation of the phenomena modeled by the PhET simulation. This has an impact on students' conceptual understanding better after learning through the [35] PhET simulation. Also, proper computer simulations to teach various scientific process skills include visualizing, classifying, solving problems, interpreting data, and designing experiments [6]. PhET's assistance in supporting science learning by providing interactive and easily accessible simulations enables the development of science process skills [9].

4. Conclusion

Based on the results of the research and discussion in this study, it can be concluded that student worksheets with PhET simulation questions are effective in improving student learning outcomes.

References
[1] Ningsyih S, Andayani Y, and Hakim A 2018 Unnes Sci. Educ. J. 7
[2] Haryono H E 2018 J. Pena Sains 5 79
[3] Erlinda N 2016 J. Ilm. Pendidik. Fis. Al-Biruni 5 223
[4] Anggraini C M, Warnasih K, and Jana P 2019 Form. J. Ilm. Pendidik. 9 1
[5] Erlin Eveline et al. 2019 J. Phys. Conf. Ser. 1233 012036
[6] Smetana L K and Bell R L 2012 J. of Science Education 34 1337
[7] Wieman C E, Adams W K, Loeblein P and Perkins K K 2010 Am. J. Phys. 48 225
[8] Ekmekci A and Gulacar O 2015 Eurasia J. Math. Sci. Technol. Educ. 11 765
[9] Moore E B, Chamberlain J M, Parson Rand Perkins K K 2014 J. Chem. Educ. 9111 91
[10] Asyhari A, Irwandani I., and Saputra H C 2016 J. Ilm. Pendidik. Fis. Al-Biruni 5 193
[11] Kim N J, Belland B R, and Walker A E 2018 Educ. Psychol. Rev. 30 397
[12] Purnamawati D, Ertikanto C, and Suyatna A 2017 J. Ilm. Pendidik. Fis. Al-Biruni 6 209
[13] Kaymakei S 2012 A Review of Studies on Worksheets in Turkey Online Submission.
[14] Celikler D and Aksan Z 2012 Procedia-Social Behav. Sci. 46 4611
[15] Lee C D 2014 Int. J. Educ. Math. Sci. Technol. 2 95
[16] Trewet C B and Nancy F 2013 Res. Soc. Adm. Pharm. 9 215
[17] Kibar Z B and Alipasa A 2010 Procedia-Social Behav. Sci. 2 733
[18] Hidayah N 2018 Inov. Pendidik. Fis. 7 171
[19] Maulani R N, Wati M, Misbah M, Dewantara D, and Mahtari S 2018 In Prosiding Seminar
[20] Santrock J W 2011 Educational Psychology (New York: McGraw Hill)
[21] Belland B R 2014 Scaffolding: Definition, current debates, and future directions (New York: Springer).
[22] Van de Pol J, Volman M and Beishuizen J 2010. Educ. Psychol. Rev. 22 271
[23] Morgan K and D W Brooks 2012 J. Sci. Educ. Technol. 21 513
[24] Supeno S and Maryani M 2019 FKIP e-PROCEEDING 3 101
[25] Wu L and Looi C K 2011 A reflective tutoring framework using question prompts for scaffolding of reflection (Berlin: Springer).
[26] Widoyoko E P 2016. Evaluasi program pembelajaran panduan praktis bagi pendidik dan calon pendidik (Yogyakarta: Pustaka Pelajar)
[27] Hake R R 1998 Am. J. Phys. 66 64
[28] Zainuddin Z, Hasanah A R, Salam M A, Misbah M and Mahtari S 2019 J. Phys. Conf. Ser. 1171
[29] M Wati, Hartini S, Hikmah N and Mahtari S 2018 J. Phys.Conf. Ser. 997 012044
[30] Mastuang M, Misbah M, Yahya A and Mahtari S 2019 J. Phys.Conf. Ser. 1171 012018
[31] Arsyad A 2011 Media Pembelajaran (Jakarta: PT Raja Grafindo Persada)
[32] Dimyati and Mudjiono 2009 Belajar dan Pembelajaran (Jakarta: Rineka Cipta)
[33] Razzaq L M and Heffernan N T 2009 To Tutor or Not to Tutor: That is the Question. In AIED (pp. 457-464)
[34] Ge X, Planes L G, and Er N 2010 Interdiscip. J. Probl. Learn. 4 30
[35] Kroothkaew S and Srisawasdi N 2013 Procedia-Social Behav. Sci. 9320 23