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THE DEVELOPMENT OF PhET-ASSISTED INQUIRY-BASED ELECTRONIC WORKSHEETS TO IMPROVE COMMUNICATION AND COLLABORATION SKILLS

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Abstract

Communication and collaboration skills are part of the 21st century skills that are very important for students to possess. Science learning with certain characteristics can be a means to develop these abilities. The aims of this study were: 1) to develop a viable PhET-assisted inquiry-based electronic worksheets, (2) to find out the practicality of the developed products based on student responses, (3) to test the effect of using the product to increase communication skills, and (4) to test the effect of using the product to increase collaboration skills. This research was a Research and Development (R&D) with a 4-D model consisted of define, design, develop, and disseminate. Product trial design using one group pretest-posttest on 32 students of class VIII B at SMPN 05 Depok. The data collection instruments consisted of product validation sheets, student response questionnaires, communication skills observation sheets and collaboration skills observation sheets. The product viability data were examined qualitatively and quantitatively descriptively. The paired sample t-test and effect size analysis were used to check the effect of the product toward communication and collaboration skills. The results show that PhET-assisted inquiry-based electronic worksheets are: 1) declared suitable for use in science learning, (2) considered practical for use in science learning, (3) effective in improving communication skills, (4) effective in improving collaboration skills.

Keywords: E-worksheets, Inquiry Learning, PhET, Communication Skills, Collaboration Skills

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INTRODUCTION

The 21st century is a century of openness marked by the rapid development of information technology and the development of automation where many routine and repetitive jobs have begun to be replaced by machines (Wijaya et al., 2016). To be able to adapt, the quality of all efforts and results of human work needs to be improved. Education is the spearhead in preparing a quality workforce according to the demands of this era. Through education, a teacher can equip students with 21st century skills (Mahanal, 2014).

There are many kinds of 21st century skills should be mastered by students, however, learning and innovation skills are the most important skill for students in elementary to secondary education (Wibowo et al., 2018). Ayu (2019) states that learning and innovation skills include critical thinking skills, communication and collaboration as well as creativity and innovation. Among these skills, communication and collaboration have not received optimal attention. Even though this is very important for students to master.

Based on the observations and interviews with science teachers at SMPN 05 Depok, several problems were obtained, namely: 1) students were passive in class because learning was still teacher-centered, so two-way communication did not work optimally, 2) group work activities were not accompanied by activities that activate students, so that students only rely on one or two people in the group and the division of tasks is not clear, 3) the teacher has not maximized the use of media and learning models that activate students to develop their communication and collaboration skills.

These problems indicate that in learning activities, there is still a lack of students' communication and collaboration skills. One of the reasons underlying these problems is the inaccuracy of learning models and methods and the lack of teaching materials that support the development of communication and collaboration skills. This is in accordance with the opinion of Daniah (2020) which states that science learning should be carried out through scientific inquiry to foster the ability to think, work, act scientifically and communicate it as an important aspect of life skills. Therefore, science learning emphasizes providing direct learning experiences through the use and development of scientific processes and attitudes. As a solution to these problems, it is necessary to apply a learning model inquiry assisted with practicum activities using PhET.

Inquiry learning is a learning model that emphasizes students to be actively involved in searching for themselves, submitting opinions, responding, and solving problems either individually or in groups (Meo et al., 2021). Therefore, it trains communication skills through the activities of submitting opinions and responding and training collaboration skills in solving problems in groups. Stimulus activities are very important for training students' communication skills include reading, listening, observing, converting information, assessing, analyzing, synthesizing information and solving problems through language (Zubaidah, 2018). Maasawet (2011) also explains that collaboration skills can be raised through a practicum in learning. It is because practicum can lead to interactions that require students to be able to work well together in observation, practicum, and discussion activities in groups. These various activities are included in the step of inquiry.

In inquiry, the presence of practical tools and materials is needed, but not all of them are available in class. That is why, virtual labs (v-labs) can be used as a solution. There are many kinds of v-labs but one of the most popular is PhET. Mubarrok & Mulyaningsih (2014) states that PhET is a fun interactive simulation media software with a discovery base (*researched base*d). PhET can be used as an approach that requires involvement and interaction with students, provides dynamic feedback, educates students to have a constructivist mindset, makes learning more interesting because students can learn and play at the same time (Perdana, 2017). Practicum activities also require worksheets which is used as a guide in carrying out practicums. Student worksheets are one of the learning resources as facilitators in learning activities that teachers can develop. Worksheets is also included as a learning media because it can be used in conjunction with other learning resources or media (Rohaeti & Widjajanti, 2009). Inquiry based worksheets that is assisted by simulation can make students more active in learning (Auliyani, 2018).

Based on these problems, this study will discuss the development of inquiry-based worksheets that assisted by PhET on work and simple machines topic to improve communication and collaboration skills. In details, the objectives of this study are: 1) to produce appropriate PhET-assisted inquiry-based electronic worksheets, (2) to examine the its practicality based on student responses, (3) to test the effect of the e-worksheets toward students' communication skills, and (4) to test the effect of the e-worksheets toward students' collaboration skills.

METHOD

Research Design

This study was Research and Development (R&D) with the development model used is 4-D according to Thiagarajan & Semmel (1974) which includes stages define, design, development, and dissemination. In product trial, One Group Pretest-Posttest Design was applied by taking an initial measurement (pretest) of one group of test subjects, carrying out the treatment using the developed product within a certain period, and then make the final measurement (posttest) on research variables. Figure 1 illustrates the research design (Sugiyono, 2011):

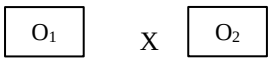


Figure 1. One group pretest-posttest design

Research Objects

This study involved science content expert, media expert, science teachers, and also used 32 students of class VII B SMPN 05 Depok as test subjects.

Data Collection Techniques

The data collection instruments used included validation sheets for experts and science teachers, student response questionnaires, observation sheets for communication skills, and observation sheets for collaboration skills. All feasibility assessment data were summed up which was referred to as the actual score (X) which was quantitative. This score was then converted into a qualitative value based on the conversion of scores into a scale of four to determine the feasibility of the developed e-worksheets. The reference for changing the score to a scale of four can be seen in Table 1.

Table 1. Conversion of quantitative scores into qualitative

Score Range	Category
Mi+1,5 Sdi<X≤Mi+3Sdi	Very Feasible
Mi<X≤ Mi+1,5 Sdi	Feasible
Mi-1,5 Sdi<X≤Mi	Less Feasible
Mi-3Sdi<X≤ Mi-1,5 Sdi	Not Feasible

(Sudjana, 2009)

The increase of communication and collaboration skills were analyzed quantitatively-qualitatively. Each indicator of communication and collaboration skills is calculated on average, then calculates the percentage increase with the formula:

$$Percentage = \frac{Total\ average\ score\ of\ each\ indicator}{Maximum\ total\ score\ for\ each\ indicator}\ x\ 100\%$$

From the percentage score, it is converted into qualitative data with interval guidelines using criteria such as Table 2 below:

Table 2. Conversion of quantitative scores into qualitative

Percentage (%)	Category
80 < X ≤ 100	Very good
60 < X ≤ 80	Good
40 < X ≤ 60	Enough
20 < X ≤ 40	Less
0 ≤ X ≤ 20	Very less

(Widoyoko, 2014)

To examine the effect of e-worksheet toward communication and collaboration skills, a prerequisite test was applied. Test for normality using the test one sample Kolmogorov-Smirnov because the data used is more than 30 respondents. After the data is normally distributed, then the test is carried out with Paired Sample T-test. To determine the effect of differences in the two paired data samples, Effect Size analysis used. Effect Size score obtained from Cohen's formula then interpreted using Cohen and Morrison's criteria (2011) in Table 3 below:

Table 3. Reading terms *effect size*

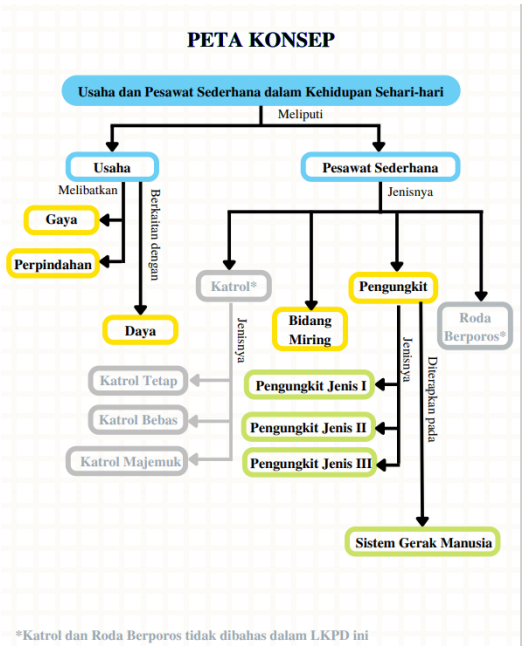
Score Range	Category
0 < d ≤ 0,2	Small Effect
0 < d ≤ 0,5	Moderate Effect
0 < d ≤ 0,8	Big Effect
d > o,8	Huge Effect

(Cohen and Morrison, 2011)

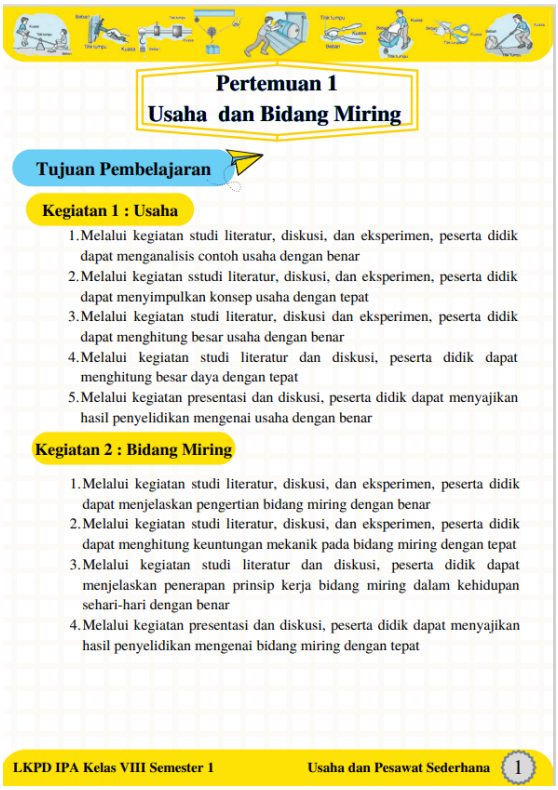
RESULTS AND DISCUSSION

The main purpose of the study is to develop e-worksheet. The development process includes four stages, namely define, *design*, *development*, and dissemination. Define phase included initial analysis, student analysis, task and concept analysis, and determination of learning objectives. In design phase, the preparation of instruments, selection of teaching materials, selection of formats, preparation of the initial draft of the science e-worksheets, review by supervisors, and revision I were implemented. Develop phase includes the development of products and instruments which were revised based on validation by expert and science teachers for revision II before field trials were carried out. Dissemination, the last phase, includes a limited distribution of products. The snapshot in certain parts of the developed e-worksheets are shown in Figure 2 and the results of validation process are presented in Table 4 below:

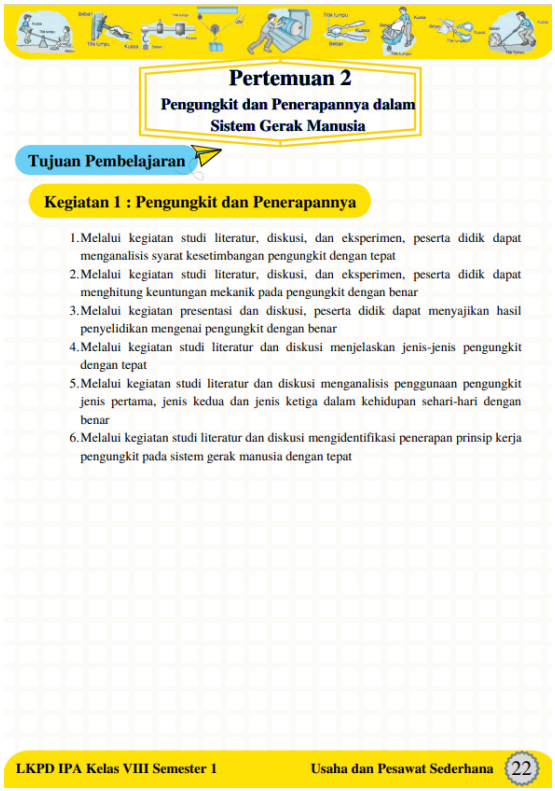
(a)



(b)



(c)



(d)

Figure 2. The snapshot of PhET-assisted inquiry-based e-worksheets: (a) cover; (b) concept map; (c) activity 1 (work and inclined plane); (d) activity 2 (lever and its application)

Table 4. Results of converting validation scores for expert and science teachers

Indicator	Total Average Score	Max Score	Category
Content Standard	19	20	Very Feasible
Language	17,75	20	Very Feasible
Science E-worksheets model	15	16	Very Feasible
Content Standard	19	20	Very Feasible
Presentation	11,25	12	Very Feasible
Usage	7	8	Very Feasible
Overall Assessment	84,75	92	Very Feasible

The developed e-worksheets were declared feasible so that field trials could be carried out. This trial was conducted on class VIII B students at SMPN 05 Depok. The trial was carried out using the design one-*group pretest-posttest design which* shows an increase in students' communication and collaboration skills. Student responses indicated that the e-worksheets included in the very good of practical category, which can be seen in Table 5:

Table 5. Student response questionnaire results

Indicator	Total Average Score	Max Score	Category
Content Standard	17.28	20	Very good
Language	17.18	20	Very good
Science E-worksheets model	34.18	40	Very good
Content Standard	14.21	16	Very good
Presentation	10.21	12	Very good
Usage	6.75	8	Very good
Overall Assessment	99.81	116	Very good

The results of improving communication and collaboration skills were known using the average of each initial assessment indicator (*pretest*) and final evaluation (*posttest*). Then calculate the percentage increase and convert quantitative values into qualitative ones based on existing conversion guidelines. The results of increasing each indicator of communication and collaboration skills can be seen in Table 6:

Table 6. Initial and final score for communication skills

Indicator	Initial Assessment		Final Evaluation	
	Percentage (%)	Category	Percentage (%)	Category
Actively engage in conversations and discussions	50.75	Enough	79.8	Good
Oral communication skills	49	Enough	69.37	Good
Receptive communication skills	47.5	Enough	76.87	Good
Written communication skills	46.75	Enough	72.87	Good
Presentation communication skills	40.5	Enough	68.62	Good
Non-verbal communication skills	51.5	Enough	77.6	Good
Average value	47.5	Enough	74	Good

Based on Table 6, it can be seen that each indicator on the aspect of communication skills has increased. The biggest increase was found in indicators showing receptive communication skills. In this study, indicators of receptive communication skills included paying attention. The indicators of receptive communication skills experienced the greatest increase because they always appeared at each stage of the inquiry. Inquiry places students not only as passive listeners, but also provides opportunities for students to be directly involved in teaching and learning activities (Pratiwi et al., 2017). Using PhET-assisted inquiry-based e-worksheets encourages students to pay attention, focus and listen attentively to the other person in each learning phase inquiry. Students were also trained to provide appropriate feedback to both the

teacher and friends when carrying out investigative activities together.

The indicator that experienced the lowest increase was the indicator showing oral communication skills. The low increase in indicators of oral communication skills is because not all students have the same courage and habits in expressing opinions orally. During the discussion process in class, oral communication skills can be seen from the ability to have the courage to speak and answer questions and present the results of the discussion correctly (Wati et al.,2019).

Table 7. Initial and final score for collaboration skills

Indicator	Initial Assessment		Final Evaluation	
	Percentage (%)	Category	Percentage (%)	Category
Manage group work well	35.75	Less	65.5	Good
Contribute to investigative activities	39	Less	72.25	Good
Cooperate actively	42	Enough	74	Good
Work together productively	38.25	Less	70.25	Good
Show a sense of responsibility	39	Less	71	Good
Adaptable to performing various roles/activities	33.5	Less	62.75	Good
Demonstrates ability to compromise, respect, and flexibility	40.5	Enough	75.25	Good
Average value	38.28	Less	70.14	Good

Based on Table 7 it can be seen that each indicator on the aspect of collaboration skills has increased. The biggest increase was found in indicators showing the ability to compromise, respect, and flexibility in work. The high increase in indicators shows the ability to compromise, respect, and flexibility in work because these indicators are always needed and raised during discussion activities to achieve common goals. This is in line with the opinion of Greenstein (2012), who states that collaboration skills are the skills to work together effectively by showing respect for diverse team members and training the will to make the necessary decisions to achieve common goals. Zubaidah (2018) further stated that with collaboration, students can discuss conveying ideas to their friends, exchanging different points of view, and seeking clarification. Collaboration teaches students to collaborate with high-level thinking such as managing, analyzing, solving problems, and creating new, deeper understandings.

On the other hand, the indicator that experienced the lowest increase was the indicator of adapting to being versatile in carrying out various roles/activities. The low increase in this indicator is caused because students are not used to using PhET for data collection in science practicum. This is supported by Khoiriyah, et al (2015) which outlines some of the shortcomings of the simulation PhET, which depends on the number of computer facilities provided by the school, the success of a learning process depends on the independence of students, and students will feel bored if they do not understand how to use computers.

After calculating the increase in communication and collaboration skills in each aspect, then an analysis of the overall increase in communication and collaboration skills is carried out which can be seen in Figure 3:

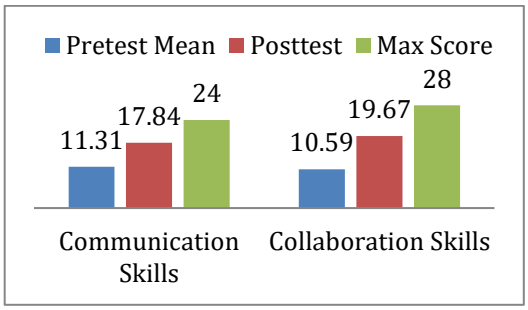


Figure 3. Increase in the average overall score of communication and collaboration skills

Based on Figure 3, it can be seen that the average score of both indicators on communication and collaboration skills has increased. To find out whether there is a significant difference between the initial and final assessment of communication and collaboration skills, is known through a Paired Sample T-test. The magnitude of the effectiveness of improving communication and collaboration skills is known through effect size analysis. The results of these two tests can be seen in Table 8.

Table 8. Test results paired sample t-test and effect size

Aspect	Paired Sample T-test	Effect Size
Communication Skills	0.000	2.64
Collaboration Skills	0.000	5.38

Based on Table 8, the value of Asymp.Sig (2-tailed) of communication and collaboration skills respectively is 0.000, or in other words that the develop e-worksheets can affect the improvement of communication and collaboration skills. The magnitude of the effectiveness of improving communication and collaboration skills also each gets a score of more than 0.8. Based on Table 3 regarding the reading conditions effect size, it can be concluded that the product developed has enormous effectiveness in improving communication and collaboration skills.

Based on this explanation, PhET-assisted inquiry can improve students' communication and collaboration skills. It is in accordance to Khabibah et al. (2018) who states that in PhET-assisted inquiry learning, students must play an active role to prove the hypothesis they have. At every step of the inquiry, students are required to demonstrate their science skills, including communication and collaboration skills. Practicum in learning can lead to interaction and the emergence of students' collaboration skills in learning. Practicum will require students to be able to work well in observation activities, practicum to group discussions (Maasawet, 2011). Nurdiyansyah and Eni (2016) also strengthen this idea by explaining the advantage of using inquiry which allows students to develop language skills, reading, and social skills. Perkins (2004) mentions the benefits of PhET Simulation including that can be used as an approach that requires involvement and interaction with students and makes learning more interesting. Thus, the use of PhET in a series of learning inquiries will enable students to develop individual communication skills and teamwork skills.

CONCLUSIONS AND SUGGESTIONS

Conclusions

Based on the data analysis and discussion that have been carried out, it can be concluded that PhET-assisted inquiry-based electronic worksheets have been developed. It consists of two learning activities, namely Activity 1 (Work and Inclined Plane) and Activity 2 (Lever and Its Application). The learning step in each activity is arranged based on inquiry learning model syntaxes and assisted by PhET simulations to facilitate the investigation. Validation and students' response results show that the e-worksheets are declared as "very feasible" and "very practice" for use in science learning. Furthermore, based on the product trial, it is clear that the implementation of the e-worksheets gives a significant effect toward communication and collaboration skills of the students. It indicates from the paired sample t-test that the value of Asymp.Sig (2-tailed) is 0.000 and the effect size score is bigger than 0.8.

Suggestions

Based on the final results and limitations of the research, the following suggestions are compiled: 1). Adequate school facilities and infrastructure are needed to support the development of electronic-based teaching materials. In addition, it is necessary to add the presentation of teaching materials in physical form even though they are developed in electronic form. 2). Before testing the product, it is better to provide directions and examples first to the students to try practicums using PhET and fill in the e-worksheets on the Canva website for other materials. 3). Inquiry-based science e-worksheets assisted by PhET to improve communication and collaboration skills can be disseminated on a larger scale.

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