IJORER : International Journal of Recent Educational Education
Homepage : https://journal.ia-education.com/index.php/ijorer
Email : ijorer@ia-education.com

p-ISSN : 2721-852X ; e-ISSN : 2721-7965
IJORER, Vol. 1, No. 2, July 2020 : 90-107

Development of Online Science Teaching Instrument Based on Scientific Approach Using PhET Simulation to Improve Learning Outcomes at Elementary School

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DOI : https://doi.org/10.46245/ijorer.v1i2.40

Article Info

Article history:
Submitted: June 16, 2020
Final Revised: July 13, 2020
Accepted: July 14, 2020
Published Online: July 31, 2020

Keywords:
Developmental research
Learning outcomes
Online science teaching
PhET Simulation
Scientific approaches

ABSTRACT

The research aims to develop online science teaching instruments based on a scientific approach using a proper PhET simulation to improve learning outcomes for elementary school students. The developed equipment is the lesson plan, students' activity sheet, learning materials, and assessment sheet of learning outcomes. The research plan is designed in One Group Pre-Test-Post-Test Design. The population in this study is all students of the fifth grade of State Elementary School Jagir I academic year 2019/2020. The results showed that there is a significant improvement in the results of online science studying through a scientific approach with the PhET simulation media. N-Gain value of class A is of 0.76 and class B is 0.70 with high criteria. The hypothesized test results showed no significant difference between class A and class B, student learning outcomes in the psychomotor area values class A in 80 when the average value of class B is 77.08, the learning results in affective domain values in class A is 80.00 in average and in class B is 80.31 with the 100% passing rate of the affective domain.

INTRODUCTION

The competency-based curriculum is designed to provide students with a learning experience with the development of attitude, knowledge and skills competencies. Therefore, the school should be able to organize contextual learning according to government standards. The main element of the education process is the teaching-learning process to transfer knowledge to students through the learning process. Learning activities foster behavioral change called learning outcomes or learning achievements. Purwanto (2011) explains that learning outcomes are behavioral changes that occur after following the learning process according to educational objectives. Learning outcomes are abilities gained by individuals after the learning process, which can provide a change of behavior for knowledge, understanding, attitudes, and skills of the students to be better than before. Learning result is one of the indicators that shows the accomplishment or failure of the goal of a learning process.

The outcomes that achieved from the learning process should refer to the objectives of education established by the government. The learning objectives of science in elementary school is the understanding of science and skills to create a product that reflects the mastery of someone's competence as a result of the learning (Citrasmi et al., 2016). Therefore, improving the quality of education and teaching in Indonesia, especially in elementary school is essential to produce human resources, which are superior and quality in every era. One of the applications of the scientific approach in 2013 Curriculum is making the student to improve learning outcomes. In essence, K13 learning is learning by emphasizing authentic learning and assessment processes to achieve the competency of attitudes, knowledge, and skills.

Learning uses a scientific approach designed to improve students' learning outcomes. The principles of the 5M scientific approach have been applied by the teacher to teach thematic science. However, the 5M principle indicators have not been fully implemented by the teacher in teaching thematic science as the teachers have no comprehensive understanding (Amir & Haling, 2018). Learning with a scientific approach is learning that consists of observing activities (to identify things you want to know), formulating questions (and formulating hypotheses), trying/collecting data (information) with various techniques, associating/analyzing/processing data (information) and draw conclusions and communicate the results which consist of conclusions to obtain knowledge, skills, and attitudes. These steps can be continued by creating activities (Kemdikbud, 2014).

Learning with a scientific approach can support students to develop hands-on and minds-on (Duda, 2010) as well as their basic ability such as communication skills, interpersonal relations, critical thinking, and problem-solving skill (Lazanyi, 2012). Learning using a scientific approach can improve the ability of students both cooperatively and collaboratively. Therefore, exploration through learning activities by observation, making questions related to observation, conducting experiments, reasoning, and communicating results through various interpretations needs to be done continuously. To support science learning, students should not only learn facts, concepts, laws, and theories in science, but they should also learn the process of how products of science are created.

Based on the observation, State Elementary School Jagir I I do not have a science lab room so the practice cannot be done properly. The materials are given through conventional learning without carrying out the scientific performance (practice). This is because of the unavailability of equipment to directly implement the practice. Based on the test results of the material in the electrical circuit chapter, the average student values of 66 with the details of 42.25% complete and 57.75% uncompleted. Susilana & Riyana (2017) explained that the learning outcomes of students as described by the cone of Edgar Dale's experience that knowledge would be more abstract if the message was only explained through verbal words. Learners only know about words without knowing and understanding the meaning contained therein, causing the low retention of knowledge. These facts show the electrical network material that has been studied has a low retention rate, so that when the repeat test was conducted, there were still many students that uncompleted the test. The students lack experience to discover their concepts. The learning is still less encouragement interaction, creativity, and motivation to learn students. Therefore, it is necessary to use learning resources or media to provide reinforcements to the material submitted. The application of interactive multimedia applications with a scientific approach can improve the quality of learning in elementary schools. The concrete thing that the teachers give will create better learning outcomes and the students will actively involve finding and build their knowledge.

In March 2020. the Indonesian government declared the closure of schools due to a Covid-19 outbreak so the learning process was diverted to online. This reinforces the researchers that it's time to study in an online class. It certainly requires the readiness of the students and teachers to achieve the objectives of the learning set. Educators should know the principles of learning and how students learn when using online learning. In designing an online learning material, there is not enough one theory to follow but rather to use a combination of theories. The learning approach should be known by

material developers to choose the best learning strategy. Learning strategies should be well chosen to motivate students, to facilitate the learning process, to shape the whole person, to serve the individual differences, to elevate meaningful learning, to encourage interaction, to provide feedback, to facilitate contextual learning, and to encourage students during the learning process. Teachers play a crucial role to organize learning and coordinate all the components that affect students in the learning process to support the success of student achievement (Asrizal et al., 2018; Tuysuz, 2010).

Online learning views the students as the active learning center and the teachers are just facilitators. The students self-construct their knowledge, conjugate information, and interpret knowledge gained from the environment. Online learning allows students to define their learning objectives so that they learn something meaningful. The use of integrated science teaching materials that are equipped with digital literacy can give a meaningful impression (Asrizal et al., 2018). The online learning process can take any place as long as it is conductive and able to help to focus. Online learning uses a technology approach according to today's learning. The delivery method of an online class is a formal and informal mix. The students will get more engaged in teaching with a variety of media formats such as pictures, videos, or audio that will provide a more enjoyable learning experience and allow students to record and store provided material in digital form. That makes the students easily accessed and re-learned at a later. Science learning that utilize more in technology is called virtual lab. It helps the students to experiment more easily and also cheaper. Virtual lab helps students understand more easily to a subject and becomes a solution for limited laboratory devices. Online classes with simulations present opportunities and challenges in terms of student involvement in scientific practice. Development in online learning is needed to ensure that students will get access to high-quality activities/knowledge.

One of the science learning alternatives offered from this case is the use of a virtual laboratory called the Physics Education Technology (PhET) simulation. These simulations belong to the University of Colorado and are suggested by Sokolowski and Rackley for science education. They were produced by the Physics Education Technology (PhET) project and have been presented as free online applications. Interactive simulations are identified as 'Easy Java Simulations (EJS)'. There are simulations on physics, chemistry, and biology fields. The main purpose of PhET simulations is to help students learn by questioning and to support making practice in learning (Fan et al., 2018). The considerations in the selection of PhET simulations are based on: (1) Learning objectives, (2) the characteristics of teaching materials or materials, (3) Student cognitive development, (4) the excess of PhET simulated media, and (5) the availability of tools and materials. Students of class V-VI elementary School are leveled as concrete operational level. The design using PhET simulated media is appropriate for those students' developmental characteristics. Learning using PhET simulations allows us to see and do something, immerse in learning, and experience the things we learn. It is expected to affect on improving learning outcomes. Students' critical thinking skills and learning independence in both classes improved after using e-handouts assisted by PhET (Ramadan et al., 2020).

PhET simulations are in line with the development of the Industrial Revolution 4.0 so that the students have good literation in technology and become proficient in using them. Students can also learn to directly explore through the PhET simulation. The simulation can create abstract physics animations. The interaction is done by pressing a button, sliding an object, or entering data. The result of the interaction will be

immediately seen. This case is strengthened by the research of Tuysuz (2010) which concluded that the virtual lab application gave a positive effect on the students' achievements and attitudes when compared to traditional teaching methods. Widowati et al (2017) states that students' thinking skills have progressed from one meeting to the next by using a virtual lab. The results of the study are in line with Ramadhan & Irwanto (2017) who state that virtual labs can improve problem-solving ability, critical thinking, creativity, student conceptual understanding, science process skills, lab skills, motivation, interests, perception, and learning outcomes. Learning with PhET simulation is projected to improve the concepts of students' understanding and improve interpersonal competence by discussion together.

PhET simulation is expected to improve the effectiveness and efficiency of the learning process so the teachers only act as facilitators while the students become the subjects who actively look for information. The virtual laboratory uses computerized models, simulations, and various other instructional technologies to replace traditional lab activities. It provides many advantages. It is done in cyberspace so experimentation does not harm yourself or others. The affordable simulation costs, once developed, the tool can be used repeatedly at no additional cost. The virtual lab allows students to work independently or collaboratively regardless of the school laboratories, chemicals, and equipment available (Herga et al., 2016).

An appropriate learning approach will be able to achieve optimal results so the learning objectives can be achieved. To achieve learning success, teachers need to pay attention to the student learning patterns, master subject matter, choose the proper learning approach, and create the most effective learning situation. According to Hosnan (2014), the characteristics of learning with the scientific approach include student-centered learning. It involves skills in processing science in developing concepts, rules or principles, and involving potential cognitive processes in stimulating the development of intellect. Here is especially students with a high level of thinking skills so it can develop their character. Learning with a scientific approach is designed in such a way so the students can actively build concepts and rules or principles through observing and formulating problems, formulate hypotheses, collect and analyze data, and draw conclusions and communicating concepts. A scientific approach provides a logic of understanding the material used. Information may come from anywhere and anytime. It does not depend on the course of the teacher. Learning conditions through scientific approaches are expected to encourage students to observe. The application of scientific approaches in learning involves processing skills such as observing, classifying, measuring, predicting, explaining, and concluding. This research aims to develop online science teaching instruments based on scientific approaches using the appropriate PhET simulation to improve the learning outcomes of elementary school students.

Based on the research objectives, the researchers describe several research objectives more specifically. They are:

- Producing an online science learning tool based on scientific approaches using PhET simulation.
- Describing the validity of a scientific approach based online science teaching instruments using the improved PhET simulation: (a) Testing the conceptual validity of the developed Teaching instruments; (b) Testing the readability of the developed Teaching instruments; (c) Testing the difficulty level of the developed Teaching instruments.

- Describing the practicality of online science teaching instruments based on scientific approaches using developed PhET simulation: (a) The implementation of online science learning activities based on scientific approaches using the PhET simulation media on material of electric; (b) The observed student activities during the learning process; (c) The found obstacles during the learning activities.
- Describing the effectiveness of online science teaching instruments based on scientific approaches using developed PhET simulation: (a) The increase in learning outcomes after implementation of online science Teaching instruments based on scientific approaches using the PhET simulation media on electrical material; (b) Students response to online science learning activities based on scientific approaches using PhET simulation.

RESEARCH METHOD

General Background

This research uses a developmental method. The teaching instruments are developed, such as the lesson plan, student activity sheet, learning materials, and the assessment sheet of learning outcomes on material of electrical circuit. The development of the device is guided by the Model 4-D. The developmental research conducts in several phases, namely defining, designing, developing, and disseminating. The implementation of Teaching instruments uses the One Group Pre-Test-One Group Post-Test design because it uses only one group without comparison. A group has been given a treatment using a scientific approach assisted by the PhET simulated media, then assessed to determine the level of achievement of a predefined indicator. Design research presented in Figure 1.

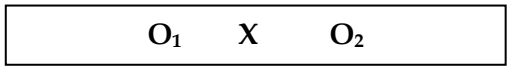

Figure 1. Research design.

Sample / Participants / Group

This research was conducted at State Elementary School Jagir I I/393 Surabaya in the even semester in the academic year 2019/2020. with three meetings plus pre-test and post-test. The research subject is a scientific approach-based teaching instrument using PhET simulations. The test subjects were students of the VA class as much as 20 people and VB class of 20 people at State Elementary School Jagir I I/393 Surabaya. The study was conducted in the even semester in the academic year 2019/2020. The researchers acted as the teachers.

Instrument and Procedures

The Data of the learning process, the student activity, and the obstacles during the learning are obtained through observations by two observers. Those data are noted using the observation sheets and rubric. Learning Data is obtained through an instrument test to measure and record students' learning outcomes on the material of electrical. The instruments are in the form of 30 questions multiple-choice tests with four options of answers each question. The test is performed twice, namely pre-test and post-test. The student response Data uses a poll that collects information about response to readability and difficulty level in understanding learning materials and student activity sheets, the use of PhET simulations in learning, the teacher explanation during learning activities, the teacher guidance when working on student activity sheets during

activities, as well as problem/sheet of assessment of learning outcomes used. The student response poll is given after the entire learning process is completed.

Data Analysis

Teaching instruments are worthy of the research when fulfilling elements: valid, practical, effective. The validity is determined by the scale of the passing grade which is the average score ($\bar{X}$) of the calculation results by several validators then the validity level is determined by matching the criteria.

Table 1. Device category.

Score Interval	Valuation Category	Description
3,6 ≤ P ≤ 4	Very valid	Can be used without revision
2,6 ≤ P ≤ 3,5	Valid	Can be used with a slight revision
1,6 ≤ P ≤ 2,5	less valid	Can be used with many revisions
1 ≤ P ≤ 1,5	invalid	Not usable yet and still require revision

The instruments reliability is determined by the calculation of two observers with the degree of reliability is calculated by using formula (Borich, 2007):

$$Percentage\ of\ Agreement = \left[1 - \frac{A - B}{B + A}\right] X\ 100\%$$

Description:

A: Frequency of the aspect assessed by the validator/observer by providing high frequencies; B: Frequency of the aspect assessed by the validator/observer by providing low frequencies. The Student activity observation instrument is reliable if the reliability value R ≥ 75% (Borich, 2007)

The analytical techniques for readability and student activity sheet are done in a qualitative descriptive based on the following readability. The percentage of learning material readability and student's activity sheet can be calculated using the formula:

$$Persentase = \frac{Number\ of\ students\ answered\ yes/agree}{Sum\ of\ all\ students}\ x\ 100\%$$

The percentages earned are then interpreted according to Table 2.

Table 2. Readability value of the device.

Percentage	Category
> 60%	Low
40-60%	Moderate
< 40%	Height

The level of difficulty analysis of learning materials and student's activity sheet is completed in a qualitative descriptive based on the following difficulty level. The percentage of difficulty level of learning materials and student's activity sheet can be calculated using the formula:

$$percentage = \frac{Number\ of\ students\ answered\ yes/agree}{Sum\ of\ all\ students}\ x\ 100\%$$

The percentage earned is interpreted according to Table 3

Table 3. Device difficulty value.

Percentage	Category
>81%	Very hard to understand
61% - 80%	Hard to understand
41% - 60%	Less hard to understand
21% - 40%	Easy to understand
<21%	Very easy to Understand

The results of learning are analyzed by calculating the observation results (perceived by observation) based on the average value of each section in the lesson plan and conventions using the criteria in Table 4.

Table 4. Criteria for learning implementation.

Average score Interval	**Category**
>3,6	Excellent
2,8 – 3,6	Good
1,9 0 2,7	Fair
1,0 – 1,8	Bad

Percentage of students ' activity is calculated using the following formula:

$$P = \left(\frac{\Sigma K}{\Sigma N}\right) x100\%$$

Description:
P: The percentage of the student activity; ΣK : The number of frequencies each appearing activity; ΣN : The number of all activity frequencies.

The obstacles in the teaching implementation are analyzed in descriptive qualitative, the data are obtained based on the notes by the observers. The researchers then provide solutions to overcome them. The percentage of responses is obtained then interpreted according to Table 5.

Table 5. Student response category.

Percentage	**Category**
81% - 100%	Very good
61% - 80%	Good
41% - 60%	Fair
21% - 40%	Bad
0% - 20%	Very bad

In this study, the data processing of pre-test and post-test results uses the SPSS V16 program. From the pre-test and post-test results, the data then analyzed in a descriptive quantitative processing. The accomplishment of the indicator is calculated using the formula:

$$The\ accomplishment\ of\ the\ indicator\ = \frac{\Sigma\ Students\ who\ reach\ the\ indicator}{\Sigma\ Students}\ x\ 100\%$$

An indicator is said to be accomplished if ≥ 70% of students reach the indicator. The students are individually is said to be accomplished when the average achievement of

indicators that represents the learning objective meets the minimum accomplishment criteria of State Elementary School Jagir I that set at 75. Student knowledge learning outcomes are analyzed by using the following formula.

$$Value = \frac{Score\ earned}{Maximum\ Score}\ x\ 100$$

The classification of learning results in a classical formula is calculated:

$$Classical\ accomplishment = \frac{\Sigma\ Individual\ learners}{\Sigma\ students}\ x\ 100\%$$

The learning result is said to achieve the classical accomplishment if it meets the criteria of accomplishment of ≥ 85% (Anwar, 2016). The pre-test and post-test scores gained by students also demonstrate the effectiveness of the learning performed. To determine the improvement factor (gain), the researchers analyzed using the Hake formula as follows.

$$g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

g is the improvement in learning outcomes, S_{post} is the average score in the post-test, S_{pre} is the average score in the pre-test, and S_{max} is the maximum score. Hake classifies gain into g -high ($g \geq 0.7$), g-medium ($0.7 > g \geq 0.3$), and g-low ($g < 0.3$). Testing prerequisite analysis: (1) Conducting normality tests using Kolmogorov-Smirnov test statistics with a level of α significance = 0.05; (2) Conducting homogeneity test with Levene test with the equivalent of α-significance = 0.05. Hypothesis testing with an Independent T-Test with a significance of 0.05 is used to determine if there is a difference in learning outcomes for each class of one variable (N-Gain). The hypotheses tested in the Independent T-test include: H_0 = There is no significant difference between the average N-Gain between classes; H_1 = There is a significant difference between the average N-Gain between classes. Basic decision Making: If the value of Sig. (2-Tailed) > 0.05, then H_0 accepted and H_a rejected; If Sig. (2-Tailed) < 0.05, then H_0 rejected and H_a accepted. The data analysis technique of affective learning outcomes by applying scientific approach based learning is calculated by the following formula:

$$\text{Affective Learning score} = \frac{\Sigma\ \text{Acquisition Score}}{\Sigma\ \text{Maximum Score}}\ x\ 100$$

The description in the affective assessment development can be seen in Table 6.

Table 6. Affective learning results category.

Value	Category
0-20	Very bad
21-40	Bad
41-60	Fair
61-80	Good
81-100	Excellent

The students are said to be accomplished when obtaining affective learning outcomes with minimum submission criteria value of 75. The data analysis of psychomotor learning outcomes are gained by applying teaching based on the scientific approaches then calculated with the following formula:

$$\text{Psychomotor learning score} = \frac{\Sigma\ \text{Acquisition Score}}{\Sigma\ \text{Maximum Score}}\ x\ 100$$

Table 7. Category of psychomotor study results.

Value	Category
0-20	Very bad
21-40	Bad
41-60	Fair
61-80	Good
81-100	Excellent

The students are said to be accomplished when obtaining psychomotor learning outcomes with minimum submission criteria value of 75.

RESULTS AND DISCUSSION

The teaching instrument are said to be appropriate in this research when fulfilling these elements: valid, practical and effective. The validity of the teaching instruments can be seen from the conceptual validity, readability of the device, and the difficulty of the device. The practicality of the learning tools can be seen from the implementation of teaching instruments and the obstacles that come then the students can solve. The effectiveness of the teaching instruments that used by students can be seen from the activities of students in the process of learning. It comes from the students' responses during and after learning performed and the improvement of student outcomes after learning.

Teaching instruments are considered as valid if they meet the criteria: 1) The conceptual validity of teaching instruments is appropriate if shown between $2.6 \leq SV \leq 3.5$; 2) The legibility rate of the student's handbook and students activity sheet is appropriate if shown between 40% to 60%; and 3) The difficulty level of student teaching book and students activity sheet maximum should be 40% with categorized as easy to understand. The data validation results are analyzed in descriptive qualitative. The validity is determined by the passing grade with the average score ($\bar{X}$) of the assessment results of the device by the validators. It determined the validity level of the device developed by matching the criteria.

Table 8. Validation results.

Validity	Device	Average Rating	*Percentage of Agreement*	Description
Conceptual validity	Syllabus	3,46	94,05 %	Very Valid
	Lesson plan	3,44	95,80 %	Very Valid
	Evaluation sheet	3,35	93,88 %	Very Valid
	Student activity sheets	3,44	94,12 %	Very Valid
	Student learning materials	3,35	93,88 %	Very Valid
Readability level	Student learning materials	88%		High
	Student activity sheets	90%		High
Difficulty level	Student learning materials	32,5%		Easy to understand
	Student activity sheets	33,9%		Easy to understand

The selected learning activity is a website-based online learning model. The website-based learning Model is designed by integrating learning with websites into conventional face-to-face learning programs (Prastowo, 2013). Conventional in-face

learning processes are virtually full-fledged while providing the opportunity to interact with one another to communicate directly and face-to-face if needed through an Internet application. The teacher uses laptops, internet, and mobile phones as a learning tool, while students simply use their parents' mobile phones to access learning materials and learning activities. The e-learning model uses WhatsApp group media to coordinate the students and give explanations and share tasks or links, Google form for work on the pre-test and post-test, and scoring. The virtual learning is assisted by Google meet and Hangout meet to perform online learning and face-to-face with students in the implementation of learning activities following the lesson plan that has been assigned the syntax. For material enrichment, the teacher uses learning videos that uploaded on YouTube so the students can re-watch and understand the learning activities repeatedly.

The practicality of teaching instruments is reviewed the process of learning through the practice of learning, the student activity, and the obstacles during implementation. A learning tool is said to be practical if 1) the performance of learning earns an average of a minimum observation score of 3.00 with a good category; 2) The percentage results of the observed student activity at least 66% in the good category; 3) the obstacles found during learning activities can be overcome. The aspect organized in RPP was 100% carried out for 3 meetings. The average implementation rate of the lesson plan reach 3.30 – 3.47 with a percentage of agreement 90.5 – 93.6. The aspect organized in the lesson plan reaches 100% carried out for 3 meetings. The average implementation rating in the lesson plan reach 3.30 – 3.47 with a percentage of agreement 90.5 – 93.6.

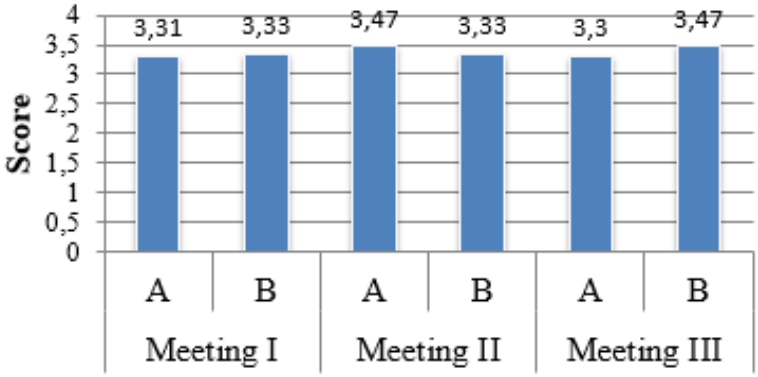

Figure 2. Average score for learning.

On average, most activities of the student in class A are reading and working on student activity sheets while the lowest activity is responding to friends' presentations. On average, the highest activity in class B is reading to observe and concluding the result while the lowest activity is responding to friends' presentations. Activities in responding to the friends' presentations are noted in the learning process because the students cannot actively give questions or respond when their friends make presentations. Student activity observations are described in Figure 3.

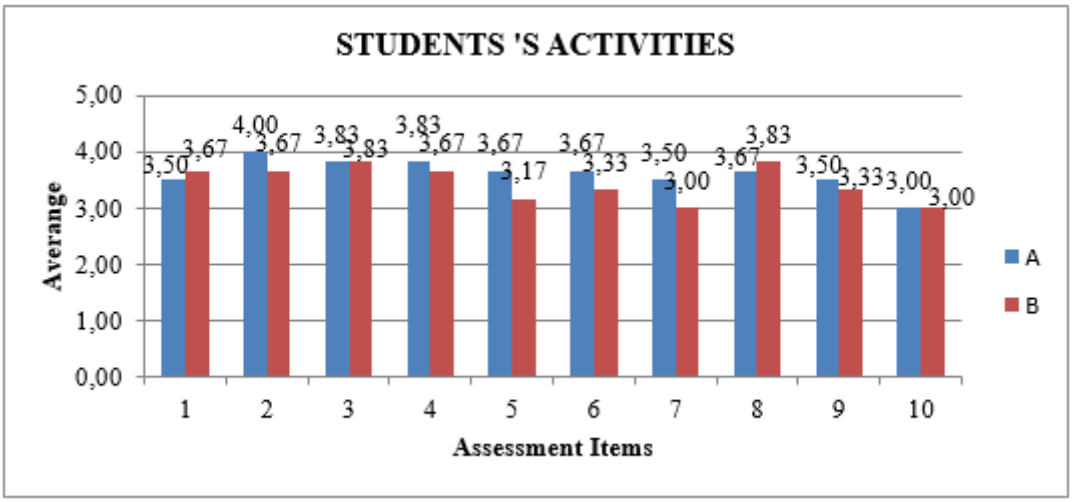

Figure 3. The average score of students' activities.

Description of the evaluation aspect: 1. Attention to teacher explanation, 2. Read learning materials and work on the student activity sheets, 3. Observe, 4. Convey the question, 5. Experimenting with PhET simulation, 6. Analyzing the data from the experiment results, 7. Presenting the results of the experiment, 8. Conclude the results of the experiment, 9. Communicating the experiment results, 10 Respond to friend presentations. The obstacles that occurred during the learning activities are noted by two observers. The obstacles samples such as the students that are not friends yet to use the PhET simulation or define the variables in the experiment. Both observers use an observation sheet of the obstacles in the learning process in Table 9.

Table 9. The implementation of overcoming obstacles.

No	Obstacles	Input/Solution
1	The students are not friendly to learn online so that it needs more preparation and more internet quota.	The teachers guide and explain directly about the guidance of the work.
2	The students have difficulty during experiments while creating electrical circuits using PhET simulations on mobile phones due to the too-small screen size.	The teachers guide students to be more thorough and the continue tries so that they will get used to using mobile phones.
3	The students still struggle too hard to analyze the results of the experiment and conclude that it needs more mentoring.	The teachers more precisely guide and explain so the students are more familiar with how to analyze and conclude experiment results.
4	The student's preparation for the presentation is less than enough. This is showed when asked by one of the students is still showing each other.	The teacher motivates and gives a resupply before presenting.

Based on Table 9, it can be explained that the constraints experienced by students occurred during the experiment using PhET simulation. The result of limited trial shows the index of item sensitivity between 0.3 – 0.60. It shows that all items (100%) are in the sensitive categories. It shows that the learning outcomes are influenced by the learning process. The effectiveness of the teaching instrument includes 1) Teaching instruments are said as effective if the average percentage of students' response is at

least 61% with good criteria; 2) the students learning results are said to improve if the value of N-gain > 0.3 with a medium category. Based on analysis of the level of achievement of indicators, class A has 2 (6.67%) indicators that are not reached and 28 (93.33%) indicators is successfully achieved, while in class B there are 5 (16.67%) indicators that are not achieved and 25 (83.33%) indicators are achieved. The overall indicator level of achievement is 4 (13.33%) unreached indicators and 26 (86.67%) successful. class A has a higher achievement of successful indicators than class B.

The pre-test result of class A ranges from 23 – 50 with the average pre-test rate of 38, while class B ranges from 23 – 47 with an average rate of 38. The post-test score of class A ranges from 67 – 97 to the average post-test rate of 85, while class B ranges from 67 – 97 to the average post-test score of 82. Based on the post-test score, the accomplishment in class A shows that 3 (15%) students do not complete while the other 17 (85%) complete. Class B post-test ranges from 70 – 97 with 5 (25%) students do not complete and 15 (75%) complete. Based on the results it can be said that the indicator is accomplished in classical.

Table 10. N-Gain value.

Initial	Class A				Initial	Class B			
	Pre-test	Post-test	N-Gain	Category		Pre-test	Post-test	N-Gain	Category
A1	33	90	0.85	High	B1	47	70	0.44	Medium
A2	37	87	0.79	High	B2	47	90	0.81	High
A3	43	93	0.88	High	B3	27	67	0.55	Medium
A4	30	83	0.76	High	B4	47	73	0.50	Medium
A5	50	93	0.87	High	B5	40	93	0.89	High
A6	43	67	0.41	Medium	B6	33	77	0.66	Medium
A7	40	80	0.67	Medium	B7	43	90	0.82	High
A8	50	93	0.87	High	B8	43	97	0.94	High
A9	23	67	0.57	Medium	B9	23	80	0.74	High
A10	23	90	0.87	High	B10	47	83	0.69	Medium
A11	27	90	0.86	High	B11	53	80	0.57	Medium
A12	27	80	0.73	High	B12	33	90	0.85	High
A13	33	73	0.60	Medium	B13	30	80	0.71	High
A14	50	80	0.60	Medium	B14	27	77	0.68	Medium
A15	47	83	0.69	Medium	B15	27	73	0.64	Medium
A16	33	87	0.80	High	B16	33	97	0.95	High
A17	40	87	0.78	High	B17	40	80	0.67	Medium
A18	37	97	0.95	High	B18	43	83	0.71	High
A19	50	97	0.93	High	B19	37	80	0.68	Medium
A20	47	90	0.81	High	B20	40	73	0.56	Medium
Average	**38**	**85**	**0.76**	**High**		**38**	**82**	**0.70**	**High**

Based on Table 10. N-Gain value in class A ranges from 0.46 – 0.95 with 30% of students in medium criteria and 70% in high criteria. The average value of the N-Gain of Class A is 0.76 with high criteria. The N-Gain value of class B ranges from 0.44 – 0.95 with rate of 55% of students on moderate criteria and 45% on high criteria. The average N-Gain of class B values of 0.70 with high criteria. After obtaining the pre-test and post-test scores, the researchers conduct analysis of the value gained. The analysis used is N-Gain test. This test is used to determine the effectiveness of the given learning. N-Gain test results showed the average N-gain in class A is 0.76 with high criteria and an average N-Gain class B is 0.70 with high criteria. The results show that learning with scientific approaches with PhET media is able to improve student learning outcomes.

Teaching media develop as the advancement of science and technology. One of the media as a result of the technology is PhET simulation. PhET allows students to connect real-life phenomena and the underlying science, making those that don't appear to be visible. Besides, PhET provides direct feedback in the moment of changes made by students or teachers while using the media. It allows students to investigate causal relationships and scientific questions through a deeper simulation exploration. Therefore, the use of the PhET simulation media is expected to improve the students' conceptual understanding. besides, the integration of virtual simulations in learning will optimize students' scientific creativity (Astutik & Binar, 2018).

The results above show the real role of virtual simulation media in increasing the effectiveness of the use of learning approaches with interactive media. Virtual simulation Media in learning can be used as a means of sharpening the explanation of the direct learning activities, demonstrate a phenomenon using props, or replace the role of the props especially that is not possible to do before the real class. The use of a virtual laboratory has a better effect than the interactive demonstrations using real lab equipment regarding the conceptual understanding of the direct current electric circuit (Faour & Ayaobi, 2018).

It is in line with the research of Prihatiningtyas et al (2013) who states that learning results using PhET simulations is more effective than a simple teaching instrument. The teaching materials using simulated media can improve student learning outcomes when compared to using learning regular textual teaching materials. Some of those studies have shown that the use of simulated media is capable of improving students' learning outcomes. The obtained N-Gain value is used to perform the hypothesis analysis. Based on the prerequisite test results in the form of test normality and homogeneity test, the data meet the prerequisite test. Based on the results of the test of output normality using the Kolmogorov-Smirnov test, the result gives Asymp value. Sig. (2-tailed) in-class is A 0.797 and class B is 0.927. the test of normality shows that all data are distributed normally.

Table 11. Test normality.

	Class A	Class B
N	20	20
Kolmogorov-Smirnov Z	.647	.546
Asymp. Sig. (2-tailed)	.797	.927
a. Test distribution is Normal.		

Based on the results of the output of the homogeneity test using the Levene technique, the Sig value shows 0.866. These results show the data are homogeneous.

Table 12. Test homogeneity.

N-Gain			
Levene Statistic	**df1**	**df2**	**Sig.**
.029	1	36	.866

The prerequisite test for data analysis has been fully completed so the data can be tested with a test T-independent test. The results of the statistical test output of the

Independent T-test showed a value of T is 1.305 with a value of Sig. (2-Tailed) is 0.200. These results indicate there is no significant difference between class A and class B.

Table 13. Independent T-Test.

		Levene's Test for Equality of Variances		T-test for Equality of Means					
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
									Lower Upper
N-Gain	Equal variances assumed	.029	.866	1.305	36	.200	.06105	.04679	-.03385 .15596
	Equal variances not assumed			1.305	35.949	.200	.06105	.04679	-.03386 .15596

Table 13 shows that the learning process in both classes that given the same treatment shows no different results. These results show that teaching instruments developed and applied to both classes are appropriate for use for broader trials because it can give equal/consistent results. In the students' learning results in the domain of psychomotor, the average value of class A is 80.12 with the details of 90% (18 persons) complete and 10% (2 people) do not complete. The average value of class B is 77.08 with the details of 85% (17 persons) complete and 15% (3 persons) do not complete. The result of the overall psychomotor of students is 87.5% (35 people) complete and 12.5% (5 persons) do not complete. It is in line with the achievement of Hernawati, et al. (2018) who state scientific approaches have an appropriate learning syntax to enhance and develop students' academic skills and give them a variety of skills. Triyuni (2016) stated that the scientific approach provides a positive and good learning environment that is conducive to improve the students' skills. Therefore, the exploration through learning activities in observation, making questions related to observation, conducting experiments, reasoning, and communicating results through various interpretations are still needed to improve.

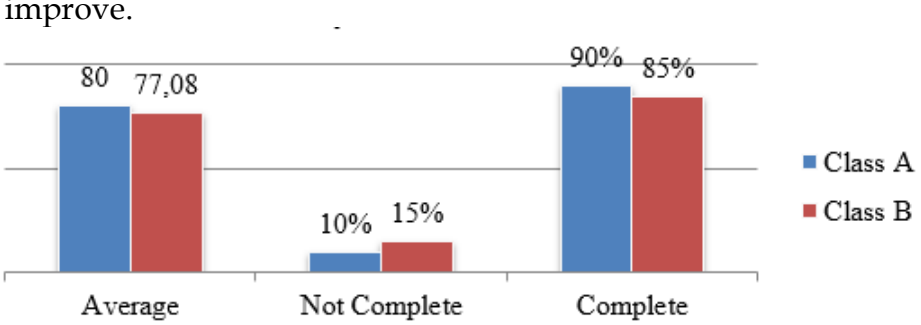

Figure 4. The learning results of psychomotor domains.

Based on Figure 4 below, the student learning outcomes in the affective domain gain class A 80.00 and in class B 80.31 in the average value. Both classes accomplished amounted to 100% in affective domains. According to Cahyani et al. (2014), multimedia-assisted learning can improve the attitude of curiosity, cooperation, creativity, and

environmental awareness. The learning situation used at the moment is an online learning situation. The online learning is well organized according to the achieved indicators. The learning process is completed according to the schedule prepared by the teacher. The students attend online classes at the scheduled time.

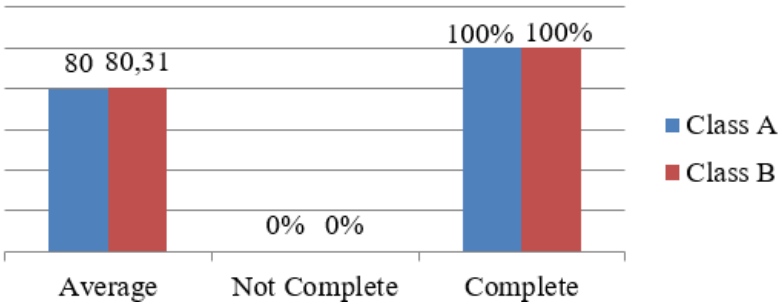

Figure 5. The learning results in affective domains.

The learning process of a scientific approach based using PhET simulations makes the students interested to pay attention to the lessons or other materials. A response poll is given to all students who join the learning in Class A and Class B. the average percentage of students' response rate is 88%. The percentage of students' responses to the teacher's in describing learning material is 85%. The response of the students in scientific activities tend to be high. It can be seen from the average of 88% who say comforted in how the teachers give guidance while observing, 90% say comforted in how the teachers give guidance while questioning, 93% say comforted in how teachers give guidance when experimenting, 85% comforted to how teachers give guidance when associating, and 83% comforted in how teachers give guidance when communicating. Overall, the students give positive responses to the learning process. It can motivate the students to boost their attention and get them involved in a fun and meaningful learning experience. This motivation encourages the students to perform learning activities as perceived by the observers. The high response rate of the students can indirectly help themselves to achieve high learning outcomes. From the response conclusion, the students are generally attracted to scientific approach based learning components using PhET simulations. They agree that further learning should be given in the same way. They also state that learning based on scientific approaches using PhET simulations is interesting and makes it easier to receive lessons. Developing learning science subject emphasizes the discovery of concepts through scientific approaches so the students have experience with the objects they learn. The experience can be gained by students through online learning with PhET media. Students can dabble their experiments virtually. Learning with the virtual media is in line with the theory of experience that Edgar Dale has discovered. His theory gives the idea that student learning experiences can be done through the process of doing or experiencing where the learning way has higher accuracy because the outcome tends to be concrete (Sanjaya, 2010). Learning with PhET simulations has the benefit of being able to make the invisible appear and provide multiple representations (macroscopic, microscopic, graphics, etc.) of abstract concepts (Ceberiol et al., 2016).

Learning is aimed to find out and to do an action to make the students to gain understanding and build on it still by tutored by the teacher. Learning goes as the process of finding a concept that built-in mind to make the learning meaningful. Yulianti et al (2018) stated after inquiry-based learning with PhET simulations were introduced, some changes occurred to the problem-solving strategies used by some

students to become more scientific, structured, and memory-based. The meaningful learning outcomes are expected to have a high retention power as students understand more deeply.

That way is coherent with the Wieman, et al (2008) who explain that PhET simulation works better when combined with activities that allow students to work directly with programs to build their conceptual understanding of science through exploration. This kind of activity can be done with small study groups in lab or recitation or as a homework assignment. Learning science requires the students to observe objects and events, ask questions, acquire knowledge, develop explanations of natural symptoms, test the explanation in different ways, and communicate the idea to another group. Learning science in observing objects are generally done in science laboratories. However, not all schools have laboratories. Therefore, the solution is using a virtual laboratory where the students can experiment virtually and get the necessary data. One of the virtual labs is through the PhET application, which contains physical, chemical, biological, and mathematical materials. The use of the PhET application is expected to improve better results of science learning if compared to conventional classes. Based on Edgar Dale's theory of expressing knowledge, it can be absorbed by 90% when presented through real experimentation or simulated. Online learning should be able to provide a variety of learning activities to accommodate different learning styles. The students will choose the most appropriate strategy to obtain their learning needs.

Various pre-learning activities can be used in preparing students about the lesson and to keep them connected and motivated to learn by online. Before it is conducted, the students should be shown about the lesson target so they knew when and how to achieved the outcome of the lesson. The students must be notified of learning requirements so they can check if they are ready for the lesson. Necessary instructions should be given beforehand so that students will use interactive simulations in line with their purpose. To benefit from interactive simulations at the highest level, results should be discussed in groups, and individual presentations should be ensured (Araci & Yilmas, 2020).

CONCLUSIONS

Teaching instruments that developed (lesson plan, student activity sheets, student learning materials, and assessment sheet of learning outcomes) in this study successfully fulfill the criteria for validity, practicality, and effectiveness. The validity of teaching instruments includes conceptual validity, readability, and the difficulty levels. The practicality of teaching instruments includes the implementation of learning, the student activity, and the obstacle during learning activities. Learning effectiveness involves the improvement of learning outcomes and the student responses to learning activities. Based on the fulfillment of validity, criteria, and effectiveness criteria, the teaching instruments developed are appropriate to use in the learning process. The research implication is that a qualified online science learning based on a scientific approach using PhET simulations can be used to enhance the learning outcomes of elementary school students in science learning. Further research that can be done is to prove the quality of online science learning based on scientific approaches using PhET simulations in terms of practicality and effectiveness to increase learning outcomes in larger samples.

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