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Abstract

This study investigates the effects of science learning model reconstruction based on student needs, in order to generate more operational standards and teaching materials. The conceptual understanding through virtual laboratory appears minimal, based on the analysis addressing the demands of junior high school students in several locations in Papua. Hence, there is a necessity to reform the learning structure through the utilization of physics education technology (PhET). Furthermore, the model was reconstructed by the Model Education of Reconstruction with fundamental principles, including an analysis of the education needs based on PhET-Problem solving, to compose context describing energy materials and its changes. Expert validation on the accuracy of illustrations, drawings, tasks, exercises, and questions, indicates the model is eligible. The participants are 60 students control and experiment group for junior high school public 11 Jayapura. The results showed the science learning model has demonstrated increased virtual experiment abilities and conceptual understanding trough pretest and posttest based N-Gain. Analysis of data based normality test and independent test (T-test), meanwhile, there is a significant differences between experimental and control group. Outcome of students' responses for a separate learning model reflected positive.

Introduction

The teachers view on quality education is supposedly the primary factor applied as an absolute concept and idealism incapable of compromise. Therefore, the ability to adjust the specifications according to the purpose and benefits are paramount to their existence. Students are known to be the vision for educators at all times during the learning process. Modern technological developments are based on era 4.0 and hence, this has become impossible for educational institutions to only argue on existing conditions (Simin & Wan Athirah, , 2015; Hussin, 2018; Yusnita et al., 2018; Lawrence et al., 2019). Currently, Indonesia requires quality human resources capable of mastering, developing, and using technology appropriately. Furthermore, several technological innovations have facilitated and assisted science students, although this often lead to misconceptions (Ghavifekr & Rosdy, 2015; Daniel, 2016; Aslan & Zhu Chang, 2016)

The role of science is known to strengthen natural phenomena and explanatory science commences from a causal relationship based on emotion, experience, and perception. In order to understand science or appreciate learning, the teachers are responsible for stimulating the students to explore the purpose and educational objectives. Subsequently, the ability to comprehend science concepts is instigated through various methods. The simulation-based approach increases attractiveness towards the learning material being followed (Koyunlu Unlu & Dokme, 2014; Thompson et al., 2015).

This provides direction to enhance conceptual understanding, experiments, critical thinking, and problem solving. However, to increase interaction between learners, the teacher assigns tasks aimed at improving the quality of the learning experience. A typical indicator is the number and level of student-generated questions within the learning context (Jose et al., 2005). This type of approach significantly expands the quality of students in an area (Serena & Miguel, 2015). The knowledge of the educational conditions in an area, particularly experimental-based learning models, does not always apply physical laboratories as the only channels. These models are implored to correlate with modern times and challenges (Lowenberg & Forzani, 2009), and are therefore useful in the development of digital era to minimize inadequate laboratory conditions. Also, teachers are expected to employ technology-based techniques to encourage students to be more interactive, e.g. PhET (Dzevdeta et al., 2018; Shopi & Eka, 2018). In addition, the use of PhET and videos was

designed to achieve further effective learning goals and objectives, therefore acting as a real concept to encourage student participation. The involvement is clear evidence indicating conventional experimental methods (real laboratories) appears connected with digital principles (Jeanne & Gerrit, 2010; Moore et al., 2014; Supurwoko et al., 2017; Cathelene et al., 2018). Furthermore, the science learning model in the context of energy and its changes based on PhET-PS, was reconstructed to improve the ability to understand concepts and to perform virtual experiments. The model was adopted from model education reconstruction or MER (Duit, et al., 2012)

The problems associated in the science learning model in secondary schools in Papua generally have not maximized the virtual learning system. Despite the problems, the teachers cannot remain reserved. The existing conditions showed the teachers evenly acquired a quota to access the internet. However, the use was more effective compared to other concerns supporting the quality. Based on PhET-based learning that has been used by several researchers, no one has yet conducted problem solving-based PhET reconstruction, which can support increased understanding of concepts and the ability to experiment virtually.

Based on the problems discovered in science learning, specifically in laboratory use, the researchers were challenged to provide solutions to improve students' conceptual abilities, or teachers' conceptual understanding of science material in the context of energy and change, through developing effective learning models (Doloksaribu et al., 2013, 2014; Nursa'dah et al., 2018). However, no application of learning model based on PhET exists to support problem solving. This provides PhET the need to generate more teaching materials that can be utilized. Therefore, to improve on the lack of experimental facilities, the teaching material was reconstructed based on the material support linked to the PhET experiment. The resources developed were influenced by problem solving indicators. Furthermore, the construction of science learning model based on PhET-PS is known to direct students in the industrial era 4.0, with the capacity to improve conceptual understanding through virtual laboratory in Papua.

Literature Review

Physics educational technology is short for the PhET is a simulations interactive math and science. PhET simulations are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery. So, PhET model is an application developed to provide a simulation for science learning. PhET is an aspect of virtual laboratory through the distribution of concept simulations (Adams et al., 2008; Cengiz 2010; Pujiyono et al., 2016; Shopi & Eka, 2018, Ardiyati et al., 2019). In addition, certain studies applying the PhET approach have shown significant increase in students' creative thinking abilities. However, other methods have been struggling due to ineffective models incapable of stimulating creativity, such as research conducted by several educators (Supurwoko, et al., 2017, Zubaidah, et al., 2017, Sari, et al., 2018), and studies known to integrate science learning through PhET support (Famani, et al., 2019). Moreover, the learning process was intended to be fun and practical in order to promote comprehension

PhET is a suite of research-based interactive computer simulations for teaching and learning physics, chemistry, math, and other sciences. PhET simulations can be run online or downloaded for free from the [PhET website](#). The simulations are animated, interactive, and game-like environments where students learn through exploration. They emphasize the connections between real-life phenomena and the underlying science, and help make the visual and conceptual models of expert scientists accessible to students. PhET simulations are primarily developed for and tested with university and high school students, but have been found to be educational and fun for students "from grade school to grad school. Learning base PhET shows that students learn better when they construct their own understanding of scientific ideas within the framework of their existing knowledge, and more activity and motivation (Perkin et al,2006; Weiman & Perkin, 2008).

One of the activities that can be linked to PhET is problem solving ability. Problem solving is the formulation of problems, designing strategies from problem solving, gathering various information, organizing data, and reporting findings. Meanwhile, decision making is the best decision or the worst of many alternatives, determining the most appropriate solution to overcome a problem, and determining the minimum risk of an option (Osbon & Sydney, 2007). Doloksaribu, & Triwiyono (2019) created PhET based simulation problem solving diagrams based on recognition of problems, problem selection, setting problem priorities, and planning problem solving. The PhET problem solving diagram is shown in Figure 1.

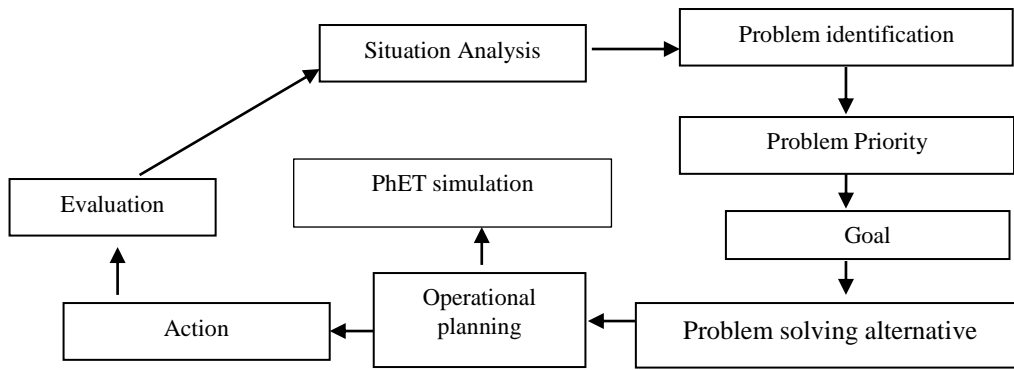


Figure 1. Merger PhET with Problem Solving

Methods

This research is an experimental, with analyzing the pretest-posttest results of the control group and the experimental group. The model education reconstruction learning was reconstructed by the MER model through problem solving-based PhET operation on material energy and its change. Validation of instruments, models and teaching materials was carried out by 3 validators through the expert judgment validation model. Treatment in the experimental class to see an increase in concept understanding and virtual laboratory abilities on science teaching materials in the energy and its changes context. Students' pretest-posttest results were analyzed based on normalized gain (N-gain). The t test analysis was carried out using the SPSS 21 method to determine the difference between the post-test scores of the concept understanding group and the experimental group. The participants comprising junior high school public students (JHSP11) were grouped into 30 per group for experiment and control. In addition, the selection was based on the level of community support and schools with high outstanding performance located in university campuses. The question criteria consist of 30 items multiple choices with the C1-C6 cognitive domain (see Table 1).

Table 1. Percentage Domain Cognitive Concept Test

Domain Cognitive	Concept	Test Number	Percentage (%)	Score
C ₁ -C ₂	Energy Sources	1-9	30	$\text{Final score} = \frac{\text{Value obtained} \times 100}{30}$
C ₃ -C ₄	Energy Changes	10-21	40	
C ₅ -C ₆	Energy implementation and its changes in everyday life	22-30	30	
Total		30	100 %	100

In addition to 5 essay items in the form of the application of the concept of energy through the disclosure of problems that need to be found a solution and how to operate PhET to get an answer or solution to problems that exist in the C5-C6 cognitive domain. The assessment criteria are as on Table 2.

Tabel.2. Problem solving Step and Operation

No.	Problem	Solving	Operation	Score
1.	How to implement changes in chemical energy in the form of waterfall into motion energy and electrical energy found in everyday life	Provide answers or solutions to these problems based on understanding the energy material and its changes	Select several existing PhET operations, and provide a reason for choosing them	20
2.	How is the implementation of energy in a remote area that still lacks electrical power	Give Answers using the energy sources found in the area's environment	Select several PhET operations with good reasons for their selection.	20
3.	How to use alternative energy if energy is decreasing.	. Give an answer, what energy might be used	Choose operational	20
4.	How to use geothermal energy	Give your answer.	Choose operational, according to the energy changes made	20
5.	How to use wind energy	Give your answer.	Choose operational, according to energy changes	20

Results

The PhET-PS based learning model is a widely applied education reconstruction technology simulation with problem solving indicators. In addition, the analytic results are further integrated into the context of energy and its changes, hence a representation was provided in Figure 2.

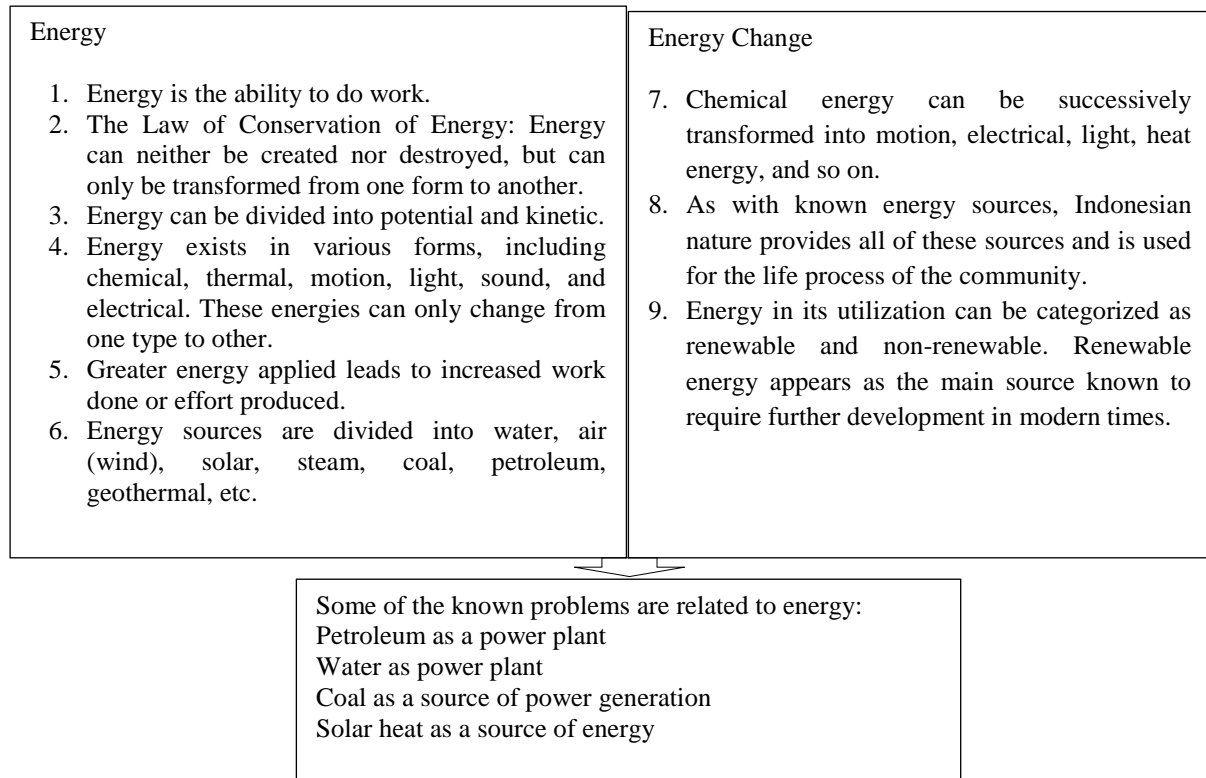


Figure 2 .The Energy and its Change Material Scheme

Incorporation of Problem solving and PhET Indicators

Problem solving indicators include (1) situation analysis (2) problem identification (3) problem priority (4) objectives (5) problem solving (6) operational plans (7) action implementation (8) evaluation. Furthermore, developing problems are common in everyday life and need to be applied in classroom learning. This usually requires laboratory work. Therefore, another alternative used is a virtual experiment based on PhET as shown in Figure 3.

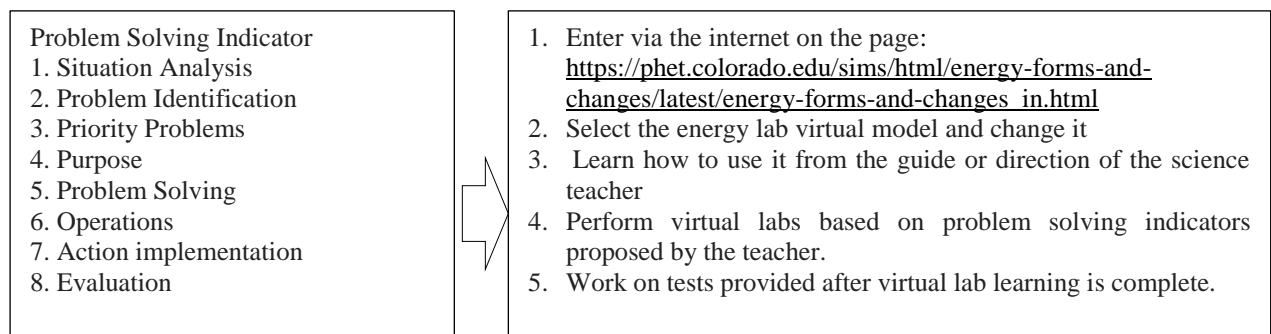


Figure 3. Common Examples of Instructions for Using PhET Scheme

Several pictures opened in PhET simulation link to material, inside after a learning operation, as shown in Figure 4.

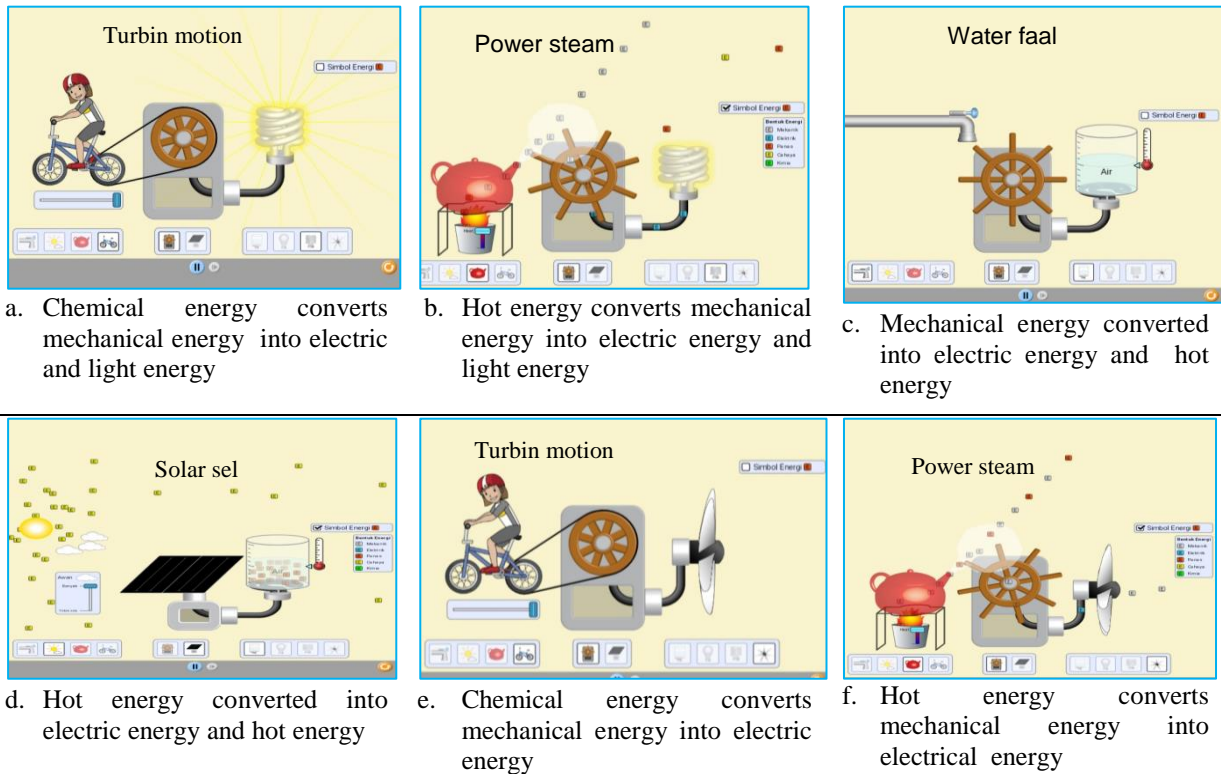


Figure 4(a-f). Step Link Problem Solving to PhET Implementation for Change Energy Context

Validation

The expert judgment validation involves the acceptance of three checks for readability and conformity of material content with respect to PhET-PS, illustration accuracy, and drawings. In addition, the precision of the tasks, exercises, and questions were individually estimated at 92.66 %, and 78 %, respectively with an average of 86,6 % (see Table 3).

Table 3. Results of Expert Validation on Energy and its changes material based on PhET-PS

Content of the text	Legibility and conformity of material PhET-PS			Accuracy of illustrations			Accuracy of assignments, exercise, and questions		
	% Score from Validator								
	A	R	NA	A	R	NA	A	R	NA
Energy Sources	86	14	0	77	23	0	85	15	0
Change of Energy	96	4	0	70	30	0	80	20	0
Implementation of Energy	96	4	0	87	13	0	95	5	0
Average	92,66	7,34	0	78	22	0	86,6	13,4	0

Note: appropriate (A), review (R), not appropriate (NA)

Acquisition of Control and Experiment Class Students

The study syntax is divided into three stages, including introduction, core, and closing. Subsequently, the control group provides the learning method, while the experimental class is assigned a PhET-PS model. Before learning, priorities were specified to recognize the initial conditions of students' conceptual knowledge shown in Table 4.

Table 4. Essay PhET-PS Score Percentage for Class Experiment

Problem/Score	EX	VG	G	EN	L
Problem (1) waterfall in Indonesia is used to provide electricity supply	Solution Score (%)				
	0	43.3	56.7	0	0
	PhET Operation Score (%)				
	3.3	56.6	40.1	0	0
	Conclution Score (%)				
	0	66.6	30.1	3.3	0
Problem (2) There are still many villages in	Solution Score (%)				
	0	60.0	40.0	0	0
	PhET Operation Score (%)				
	3.3	63.3	30.1	3.3	0
	Conclution Score (%)				
	0	66.6	33.4	0	0
Problem (3) Currently, fossil fuels are decreasing used as oil fuels, therefore present renewable energy development appears highly sought after	Solution Score (%)				
	0	63.3	33.4	3.3	0
	PhET Operation Score (%)				
	6,6	70.0	23.4	0	0
	Conclution Score (%)				
	0	60.0	33.4	6.6	0
Problem (4) of course you often hear renewable energy sources. For example solar power, water, geothermal.	Solution Score (%)				
	3.3	60.0	36.7	0	0
	PhET Operation Score (%)				
	3.3	63.3	33.4	0	0
	Conclution Score (%)				
	0	66.6	30.1	3.3	0
Problem (5) Wind is also a source of renewable energy known to be inexhaustible.	Solution Score (%)				
	3.3	60.0	33.4	3.3	0
	PhET Operation Score (%)				
	0	70.0	30.0		0
	Conclution Score (%)				
	0	70.0	23.4	3.3	

Note: Exellent (E), Very good (VG), Good (G), Enough (EN), and Low (L)

One example of student test results related to a given problem, while students provide answers that can solve the solution, in addition to being able to carry out operational PhET simulations based on the suitability of the problems given, and also provide messages from all stages carried out, such as shown in the Table 5.

Table 5. PhET based on Problem Solving Indicators

Problem	Solution	Operation	Conclusion
1. Sigura-gura waterfall in northern Sumatra Indonesia is used to provide electricity supply (PLTA) around the province, but sometimes the existing source from PLN is not running optimally. What happened to instigate the problem?	The solution expected is to keep the water flow constant, because as the water debit is reduced, small amount of water tends to reduce the strength of the waterfall.	When in a laboratory, how do you do it in PhET? Operational simulation Note the instructions in Figure 4 part c, arrows indicate water controllers. The tighter falling water results to higher water discharge to enable the turbine rotate easily. b) Moving turbines are connected with dynamos and electric current flows which can heat up water for household needs	The rain water usually causes abundant discharge to enhance the waterfall strength, and the wheel spins maximally to supply electricity to the turbine well. In addition, the water discharge appears smaller due to the influence of dry season or there are forest users upstream so that it affects the water debit. Also, the waterfall strength decreases and naturally the turbine rotation gets smaller as well as the electricity supply.

<p>2. There are still many villages in the rural communities without electricity due to the absence of PLN, although small rivers show a natural potential to generate electricity. What the people need to do?</p>	<p>Flowing water can be used as a driving source for turbines by making artificial waterfalls to complement the natural function. The measure of the waterfall produced is undetermined.</p>	<p>Same as with virtual practice PhET simulation which is picture 4 in Part A and Part E.</p>	<p>River can be transformed into an artificial waterfall to generate power that can turn a turbine and then activates the electric dynamo.</p>
<p>3. Currently, fossil fuels are decreasing used as oil fuels, therefore present renewable energy development appears highly sought after. Like the sun? Why is sun really needed as an alternative source of energy?</p>	<p>Renewable energy is a referred to potential energy today, because it never runs out. A one-time fossil energy in the form of petroleum is assumed run out.</p>	<p>Note the operation in Figure 4 part d. Solar heat is absorbed by solar cells and flow as a source of electricity to be used for various purposes.</p>	<p>Sunlight is another source of energy used to generate electricity or often called solar power plants.</p>
<p>4. Of course you often hear renewable energy sources. For example solar power, water, geothermal (steam power). Several types of power plants in Indonesia consist of hydropower, PLTD, PLTS, PLTU.PLTN, and PLTB. Are these energy sources used for generating State electricity supply? How does the PLTU work?</p>	<p>As with the principle of waterfall work, geothermal water vapor can drive a turbine, turn on the dynamo and drain electricity throughout the needs of the wider community.</p>	<p>Note the operation of the PhET image 4 part a to f, where water vapor from the hot water can rotate the wheel and is connected to a dynamo to conduct an electric current in order to turn on a lamp or fan</p>	<p>Steam or geothermal energy is an alternative source of energy easily converted into electricity generation or used by a steam power company</p>
<p>5. Have you ever heard of a windmill? Wind is also a source of renewable energy known to be inexhaustible. How does the principle of angina work in generating other energy?</p>	<p>The wind is directed to move the wheel resulting to the rotation of the windmill. This cause a movement of the dynamo to conduct electricity.</p>	<p>The operation functions similarly to the propeller principle. Or as illustrated in the simulation above, the water is replaced with wind and watermills can be replaced as windmills</p>	<p>Wind is one of the best sources of renewable energy, and is always available like the sun or water vapor, geothermal, and plunging water.</p>

After learning is completed, posttests with 30 multiple choice question were also identified to ascertain the conditions of conceptual understanding. Furthermore, the percentage of posttest value and the PhET application processes are termed, very good (VG), good (G), Enough (E), less (L), and n-Gain value are high (H), enough (E), low (L) of the control class and experiment class for students at JHSP11 as shown in Figure 4.

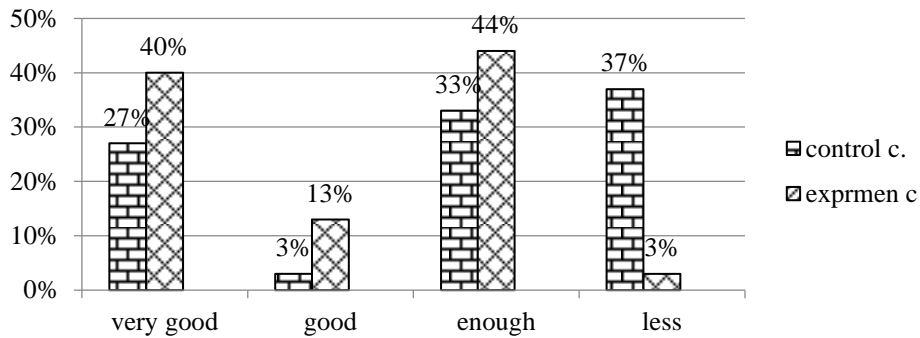


Figure 4. Graph of the Difference in Acquisition of Percentage Value of Control and Experimental Posttest

After learning is completed, posttests with 30 multiple choice question were also identified to ascertain the conditions of conceptual understanding. Furthermore, the percentage of posttest value and the PhET application processes are termed, N-Gain value are high (H), enough (E), low (L) of the control class and experiment class for students at JHSP11 as shown in Figure 5.

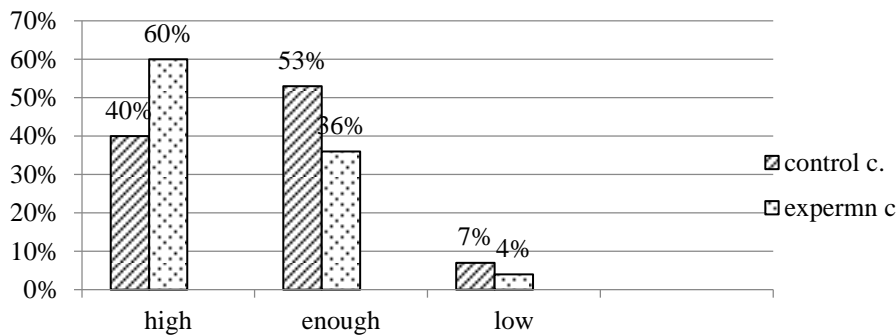


Figure 5. Difference of Percentage N-Gain Control and Experiment Group

Table 3 shows the Analysis statistical data obtained from normality test and independent test (t-test) to know different test score posttest form control class and experiment class trough SPSS 21 like shown Table 6.

Tabel. 6. Statistical Analysis, Normal test and Independent t-test

Sample Kolmogorov-Smirnov Test			
Normal Parameters	Asymp.Sig.(2-tailed)		N.
Control Class	.098 >.05	Normal	30
Experiment Class	.851 >.05	Normal	30
Independent Sample Test			
Sig.(2-tailed)	Control Class	Experiment Class	
	.002 <.05	.003 <.05	

Obtaining Response for Experimental Students Group

Table 7 shows the response acquired from the experimental students group of JHSP11. This response is categorized into very not positive (VNP), not positive (NP), very positive (VP), and positive (P) to the students' interest in the learning model. It represents the ease of conceptual understanding of the learning material based on energy and its changes, the simplicity of the application to virtual experiments. This further highlights the connection of problem solving indicators in response to PhET simulation.

Tabel 7. Percentage of Attitude of the Experiment Class for Students at JHSP11

Percentage (%) of attitude			
Experiment Group			
VNP	NP	VP	P
1.20	3.80	50.80	44.20

Discussion

Based on the results, the learning activities apply a combination of PhET model, problem solving, and the principle of education reconstruction model (Duit, et al., 1997). This model analyzes the problems faced by students with minimal experimental study conditions, although the internet situation is available. Therefore, it is effective to improve students' conceptual understanding and virtual experiments for JHSP11 and JHSP 13 due to increasing value.

A blend of PhET learning models with high-level problem solving (PhET-PS) is an approach known to enable students experience an interest in the model, and further stimulate their thinking potential (Bransford & Stein 1984; Maghan, 2017). The acquisition of control class scores with ordinary learning media and the experimental group with PhET-PS learning media show a significant variation. This proves the benefits can be reconstructed based on the students' needs in a particular field (Duit, et al., 2007), through a means of adjusting the field technology development to current learning.

Inadequate science laboratories in the school under study, are factors often responsible for not conducting proper practical activities. The use of PhET-PS model is equally helpful for students to improve the ability to understand concepts and experiment virtually. This learning pattern has been able to enhance the learning conditions (Clark & Chaberlain., 2010), due to active participation in operating PhET according to their level of problem solving abilities and also based on the instructor. Furthermore, the learning model provides minimal availability of laboratory facilities in order to aid experimental learning process through virtual practicum. This situation is in accordance with understanding the technique and learning is appropriate for students (Miftahul, 2001). Students responses based on interest in the PhET-PS model during the science learning process, were positive. One improvement in conceptual understanding and abilities of virtual laboratory experiments occurs when there are stimuli that delight the atmosphere and conditions of students.

Conclusion

The reconstructed learning model is suitable for used as a science learning model based on PhET-problem solving. In addition, a group of students from JHSP 11 Jayapura, experienced an increased performance in the experimental group using the model for conceptual understanding and virtual experiments. There was a significant variation in achievement scores between the control group and the experimental group, and the response to learning about energy and its changes was positive. Based on the results of the implementation of the learning model, the reconstruction model in the context of energy material and its changes is different significantly for control and experiment group, so the learning of the models is applied effectively.

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