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Learning Solar System using PhET Simulation to Improve Students' Understanding and Motivation

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ABSTRACT This research investigated the implementation of PhET simulation on students' understanding and motivation in learning the Solar system. The method used in this research was quasi-experimental with matching pretest-posttest group design. The research conducted in one of private Junior High School located at Padalarang, Indonesia with a number of students (n=42). The sampling technique used was the purposive sampling to determine experimental group with PhET simulation in the learning science and control group without PhET simulation. The quantitative data of this research was obtained through the objective test on the mastery concept Solar system, while the qualitative data was detected through motivation rubric and questionnaire. The result shows that the students who learn the Solar system with PhET simulation have higher both improvement in conceptual understanding and motivation than without PhET simulation as teaching media. According to the analysis result, there is a moderate correlation between conceptual understanding and motivation with the learning Solar system in the use PhET simulation.

Keywords PhET Simulation, Solar system, Students' motivation, Students' understanding

1. INTRODUCTION

Curriculum in Indonesia has progressed. During changing of curriculum, there is no other purpose to improve the quality of the learning process and the existing of learning design in the school. Therefore, the curriculum in Indonesia will continue to evolve and change to need of society and demands of the time. The Curriculum 2013 is expected to improve the quality of education in Indonesia. This is in line with the *Undang-undang nomor* 20, 2016 that the curriculum is an arrangement of objectives, content, and lesson materials and ways used as guidelines for organizing learning activities to achieve specific educational. In the development of 2013 curriculum, there are various problems and challenges among others related to the globalization and free market, environmental issues, the rapid advancement of information and technology, and transformation in the education sector as well as TIMSS and PISA materials that must be owned by the learner.

Based on the result of Program for International Student Assessment (PISA) showed that the performance of Indonesia students is still relatively low. The achievements of Indonesia evaluated by PISA for science, reading, and math are respectively is ranked 62, 61, and 63 of 69 countries (Kemendikbud, 2016). The rating and average score of Indonesia do not differ from previous PISA 2012 test result and surveys in 2012, which is also in the low material mastery group. However, the OECD not only conducts a test of those three areas, but also they measure a variety of indicators from surveying many matters related to educational activities. The result showed that the index of enjoyment of learning science of Indonesia is quite higher than index obtained by countries that scored high such as Singapore and Japan. Many works are attempted to improve Indonesia PISA score. One of the efforts is conducted by introducing the use of technology in order to help students' science literacy.

There are several aspects affecting the PISA result such as the role of parents, socioeconomic background, students' attitude and the quality of learning, and school condition and infrastructure facilities (Nizam, 2016). The progress science and technology engages the educational world improving the quality of teaching media. For example, almost all levels of educational institutions in

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Indonesia have been using computer-based media education (Fitrianingrum, 2014). In educational process, using technology will make students interested in learning science. The computer simulation is one kind of tools that are always used in teaching process to improve students understanding of difficult concept effectively instead of traditional method (Alsultanny, et al., 2014). According to Bell & Smetana (2015), the computer simulation is computer-generated dynamic models, which can explain the concept or simplified model of real-world component, phenomena, or process of concept consisting of animation, visualization, and interactive laboratory experiences. Technological advance will bring the instructional digital technologies into science classroom to make these types being interactive, authentic, and meaningful learning opportunities.

Learning Physics is one of the many lessons requiring the media to convey or explain the material (Sarofi, 2014). Physics also requires experience directly students. One of the roles instructional media is giving students experiences that cannot be obtained directly but it can be presented well using in the teaching media. The main problem of teaching and learning of science especially Physics is generally unattractive. Consequently, many students who lack understanding the concept of Physics become passive (Haya, Waskito, & Fauzi, 2014). To handle this problem, an interactive media makes students feel happy and motivated is needed to enhance students' science motivation. Therefore, the lesson will not just transfer of verbal knowledge. Motivation can encourage the student to learn or independently (Glynn & Kobala, 2006; O.Lee, 1989). Without motivation, students will not be interested and serious in the learning science.

Physics Education Technology (PhET) is one of interactive computer simulation is being used in teaching physics and chemistry. PhET Interactive Simulations Project was developed by University of Colorado Boulder (Perkins et al., 2012). PhET is aimed to be implemented at the college level, but many researched were used in middle school classrooms that focused on studying the design and use of interactive simulations (Wieman et al., 2008). The PhET project (http://phet.colorado.edu) has developed more than 80 interactive simulations. PhET simulations set through standard Web browsers and they can be media teaching as lecturing, used as laboratories virtual or as homework assignments, or used as informal resources (Wieman et. al., 2008). These cover various topics in physics and real-world applications, such as the greenhouse effect and lasers. There are simulations on chemistry topics, as well as several simulations for math, biology, and earth science.

Physics Education Technology (PhET) will be promoted as a technological media in order to help learning science. PhET is a site that provides free physics and chemistry learning simulation for download for the benefit of classroom teaching or can be used for individual learning purposes (Wieman et al., 2010). The simulations provided by PhET are highly interactive which invites students to learn by exploring directly. PhET simulation creates an animated for abstract fact or invisible phenomena to be modeled by students, such as atoms, electrons, photons, and magnetic fields. In order to encourage a quantitative exploration, simulation also offers measurement instruments including rulers, stopwatches, voltmeter, and thermometers. Users can manipulate an interactive tool; immediate animated responses visualize some related science representations such as the motion of objects, graphics, etc.

Based on these problems, the use of PhET simulation is important to improve students' understanding and motivation in learning the solar system. The use of this simulation can visualize the abstract phenomenon of the solar system. The correlation between students understanding and motivation towards implementation of PhET simulation will be further investigated. Our previous work has implemented the Stellarium as a virtual observatory to improve student's understanding of learning the solar system (Prima, Putri, & Sudargo, 2017). Other work reported the use of digital planetarium visualization to learn the solar system (Yu, K. C., Sahami, K., & Dove, J., 2017). PhET simulation was also used to conduct the lesson on quantum mechanics (McKagan, et al., 2008). PhET is used to engage and empower students in science learning. The simulations are generally usable, engaging, and effective learning tools for students (Perkins et al., 2006). Moreover, the PhET has successfully improved students' achievement in the concept of light refraction. Students feel enjoy using PhET in class (Cahyani, et. al., 2013). PhET is applied to facilitate learning on waves and sound (Maulidah, 2015). In this research, we will implement PhET simulation to improve students' understanding and motivation on learning the solar system. To best of our knowledge, this work shows the first report on the use of PhET to learn the solar system.

2. METHOD

This research used quasi-experimental, where the researcher gave an assignment, but not random assignment to subject (Creswell, 2012). The assignment was given includes pretest and post-test as administering a treatment (McMillan & Schumacher, 2001) for students' understanding of the content Solar System topic. The researcher chose the quantitative approach because of this approach based on the research objectives of this study what will be achieved. The main objective of this study is to determine the differences in students' understanding when they are learning about Solar System topic using and without PhET simulation as teaching media in the learning process. In conducted research, it used two classes as a participant to this research, where one class as a control

Table 1 Cognitive domain classification in pre-test and post-test question based on revised bloom taxonomy

Indicators	Cognitive Domains				The Percentage of Question	Number Question
	C1	C2	C3	C4		
The cause of rotation and revolution of Earth	13, 16, 20	-	-	-	15%	3
Gravity force of planet	-	1, 2, 3, 4, 6, 7, 8, 9, 11	-	-	45%	9
Rotation and Revolution of the Earth	-	-	14, 15	-	10%	2
The cause Moon rotation and revolution	-	-	-	5, 10, 12, 17, 18, 19	30%	6

Table 2 Analysis of core competence and basic competence on solar system topic *(source: permendikbud, 2016)*

Grade	Core Competence	Basic Competence	Topic	Sub Topic
VIII	3. *Memahami pengetahuan (faktual, konseptual, dan prosedural) berdasarkan rasa ingin tahunya tentang ilmu pengetahuan, teknologi, seni, budaya terkait fenomena dan kejadian tampak mata.*	3.1 *Menganalisis sistem tata surya, rotasi dan revolusi bumi, rotasi dan revolusi bulan, serta dampaknya bagi kehidupan di bumi*	Solar System	1. Component of solar system 2. Earth rounds to the Sun 3. Rotation and Revolution of Moon 4. Planets' motion Law
	4. *encoba, mengolah, dan menyaji dalam ranah konkret (menggunakan, mengurai, merangkai, memodifikasi, dan membuat) dan ranah abstrak (menulis, membaca, menghitung, menggambar, dan mengarang) sesuai dengan yang dipelajari di sekolah dan sumber lain yang sama dalam sudut pandang/teori*	4.1 *Menyajikan karya tentang dampak rotasi dan revolusi bumi dan bulan bagi kehidupan di bumi, berdasarkan hasil pengamatan atau penelusuran berbagai sumber informasi*		

group by using PowerPoint presentation of Solar System as the teaching media, and another class as an experiment that used PhET simulation which entitled "*Gravity and Orbits*" as the teaching media.

This research used the correlation analysis, which considers the relationship between two variables as defined association to share a common relationship with two variables, which are one called as "X", another one called as "Y". The method used is describing the relation of two variables based on the value of combining quantitative and qualitative method (Norušis, 2006). The method is chosen because it is the appropriate way to interpret the use PhET simulation as teaching media to improve students understanding and motivation in learning Solar System topic.

The research design used was matching only pre-test and post-test control group for both two classes (Fraenkel, Wallen, & Hyun, 2012). The implementer of the research design for two classes was student given pre-test before they used media learning as treatment and learned about the topic. The experimental group used PhET simulation entitled "*Gravity and Orbits*" developed by the University of Colorado to learn about the rotation and revolution of Earth and Moon and the impacts of them. While control group used PowerPoint Presentation as teaching media when they learned on the same topic with the experimental group. Afterward, post-test distributed to two classes is the same questions with pre-test form. The form pre-test and post-test were used is a paper test of the multiple choice to measure the students' understanding of the topic that student which have been learned during given the treatment.

This study was conducted one of a private school at Junior High School in Padalarang, West Bandung which period of 2016/2017. The school implemented *Kurikulum* 2013 of National Curriculum. The class activities in the school conducted Indonesia and English as the instructional language.

The population in this study was 8th-grade students who learn about Solar System topic in the National Curriculum. While for a sample of this study was two classes, which consist twenty-five students for each, class that chosen as a participant in this study. Because the school has three classes for each grade, so researcher used a purposive sampling technique to determine the sample that will be used in this study. To decide which classes involved in this stage, researcher two pieces picked randomly of paper that consisted of three classes name. Finally, two classes which have been chosen are VIII A and VIII B as a participant in this research. VIII A determined as the experiment group, while VIII B as the control group.

Objective test in a formed of multiple-choice question consists of twenty question to measure students' understanding of the learning Solar System topic especially the movement of the planet. The question distributed before and after learning activity for both control group and experiment group. The pre-test distributed before students learn about the topic to see their prior knowledge and post-test distributed after all content of the topic has delivered by the research in the class to see the improvement student' knowledge after they used PhET simulation for experiment group and PowerPoint presentation for the control group. The cognitive domain was used, there are C1 (remembering) until C4 (analyzing).

Table 3 Statement classification in motivation questionnaire based on aspect and condition

No	Aspect	Motivation Questionnaire		
		Statement	Total Number	Number of statement
1	Computer Attitude Questionnaire	Positive	4	1, 2, 3, and 4
		Negative	3	5,6, and 7
2	Science Attitude Questionnaire	Positive	4	8, 9, 10, and 13
		Negative	3	11, 12, and 14
3	Determination Theory, Perspective questionnaire.	Positive	3	15, 17, and 18
		Negative	3	16, 19, and 20

Table 4 Learning activities

Date	Activities
April, 8th 2017	✓ Administering the pre-test for pre-test and questionnaire
	✓ Distribute the worksheet was about components Solar System
April, 15th 2017	✓ Conducting learning process in the lab computer: Introducing PhET simulation.
	✓ Filling the worksheet was about "*Orbit*"
April. 9th 2017	✓ Conducting learning process in the lab computer "*Gravity*"
	✓ Discussion of student activities
28th April 2017	✓ Learning activity for rotation and revolution and effect of the movement in Earth and Moon in the Earth
13 May 2017	✓ Reviewing about Gravity and the effect of rotation and revolution of Earth and Moon using PhET simulation
May, 20th 2017	✓ Administered post-test and questionnaire

The classification of the cognitive domain in the objective test will present in Table 1.

According to *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 24 Tahun, 2016* is about core competence (*Kompetensi Inti*) and basic competence (*Kompetensi Dasar*) in the lessons curriculum 2013. For the topic, Solar system in the seven grade/VII, which is, stated in the basic competence 3.11 and 4.11 as the achievement for a student in a learning activity. The description of core competence and basic competence in *Kurikulum* 2013, as follows in Table 2.

To investigate the improvement of student' motivation, this research used a motivational questionnaire that adopted by three questionnaires. They are Computer Attitude Questionnaire (CAQ) by (Knezek & Christensen, 1996), Science Motivation Questionnaire by (Glynn & Kobala, 2006), and Determination Theory Perspective questionnaire (Deci, Eghrari, Patrick,, & Leone, 1994). Students filled the questionnaire before and after learning activity as a same objective test. There are twenty statements. Those are divided into three aspects questionnaire. The data that obtained from students informed four statements idea, which is "Strongly Agree", "Agree", "Disagree", and "Strongly Disagree". The classification of the statement will be presented the Table 3.

For all of the instruments that will be used has been analyzed and judged by expert judgment and using the software. For the objective test, which in form of multiple-choice questions that tested by ANATES 4.9.0 and judged by two experts judgment who professional in Earth Science subject. Moreover, the objective test distributed to another school which students have been learned about Solar System topic to test the question before objective test used in the treatment. The result of the test items was analyzed and revised to be used for the participant.

3. RESULT AND DISCUSSION

There are some findings after conducted the research by comparing two groups of the sample, which used different teaching media in a learning activity. Teaching media used for two group are control group by using power point, while experiment group by using PhET simulation. Both of two groups used different teaching media is to find 1) the improvement student' understanding in learning the concept of Solar System, 2) students' cognitive level which is most influenced by using PhET simulation in learning the concept of Solar System, 3) students' motivation in a learning activity.

3.1 Implementation of PhET Simulation as Teaching Media in Learning

Learning Activities using PhET simulation

The implementation of PhET simulation conducted in the experimental group in school. In the class, students learned about Solar System topic using PhET simulation is shown in Table 4. The table shows the implementation of PhET simulation was conducted in six meetings. The result of implementation PhET simulation can be seen from the activity in the classroom by recorded in video. In the classroom, students can use PhET simulation was provided by a researcher in the computers lab and classroom.

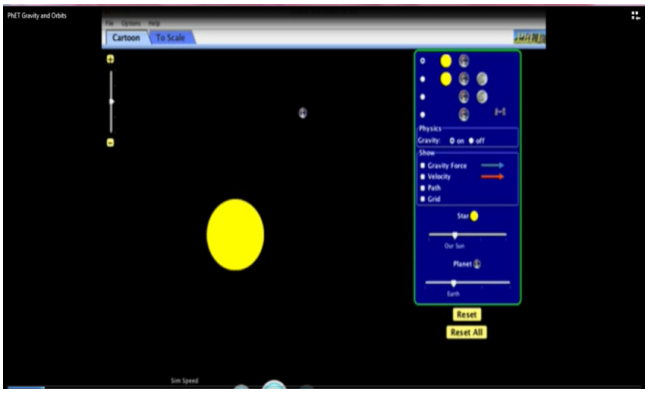

Figure 1 The implementation of PhET simulation

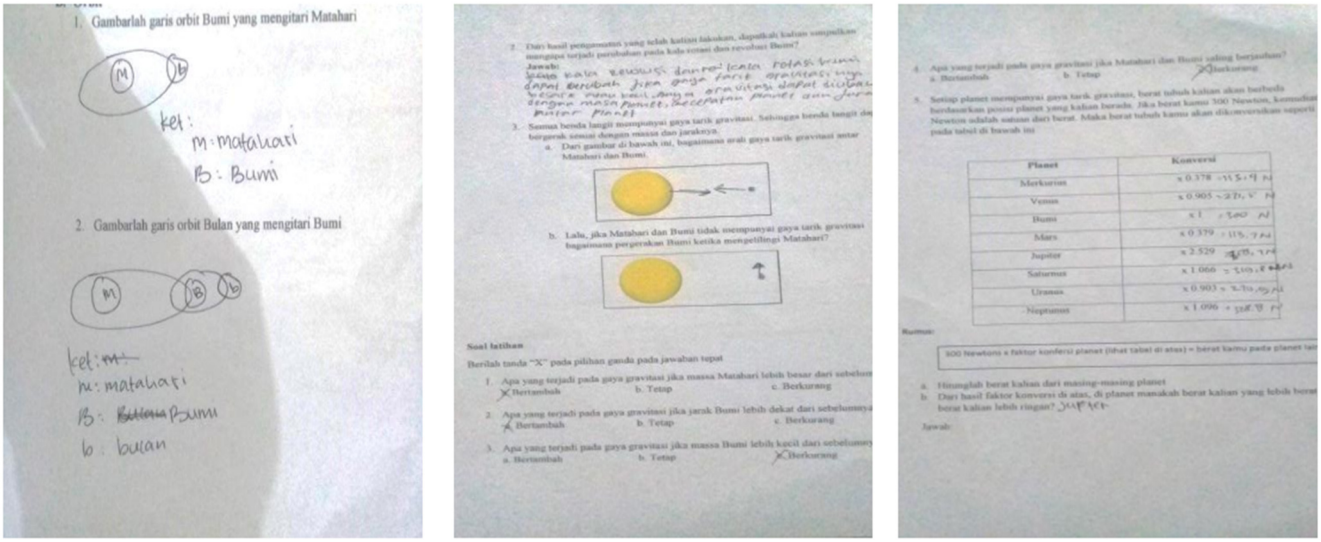

Figure 2 Example of the worksheet answered by a student

Figure 1 shows the implementation of PhET simulation in the classroom. Students have two meetings for laboratory activity and three meetings for classroom lecturing. In the lab activity, students operated PhET simulation based on the worksheet. Students worksheet for guiding students during activity and solve the problem question. Students solved the questions in the worksheet in-group discussion during performing laboratory activity. Some students can access PhET simulation to see the materials and doing exploration or games. In the worksheet that has to solve student is how planet move in orbital and the force gravity effect to movement of the planet. Students can change the variable the force gravity to see the movement of the planet. Students concluded the discussion group based on the result of the laboratory activity. While in the classroom students reviewed the material about the Solar System based on students activities on the PhET simulation. The researcher explained the material by using PhET simulation, which is same as students' PhET simulation. Students can apply the interactive simulation and explore the simulation.

Students' Worksheet

The researcher conducted the learning Solar system with PhET simulation in accordance with the time allocation based on the lesson plan. To make the lesson efficient, the worksheet for the student was prepared. The students can discuss with their group to solve the problem in the student worksheet. In the experiment group, students are categorized into five groups which are consists four or five students. The student worksheet was given to experiment group because the problem in the worksheet was designed based on analyzing with PhET simulation.

Figure 2 shows the student worksheet that has been filled by students during the learning. The figure indicates that students must answer the worksheet about Solar system. Students attempted to solve the problem question in the worksheet. The teacher gave this worksheet. In the

worksheet, there are three parts of materials and exercises to be discussed by the students. Part A discussed the characteristics of eight planets. In the activity, the researcher gave a card with a description of planets. Each group took two cards of planets and they will tell the card to another group, so the other group will write what the other group giving the description of characteristics of the planet. This activity conducted in the first meeting after they took the pretest. The second meeting, the researcher conducted the activity in the lab computer, so students will implement PhET simulation. A general description of PhET simulation was introduced to students. The instruction was given to use PhET simulation especially in the simulation *"Gravity and Orbits"* was also given. To make timely efficient, the problem about the orbits of the planet is distributed to all of the student's groups. They worked in the group to operate PhET simulation. This activity placed in Part B consists of four questions that should be discussed by the students. For Part C, students discussed Solar system at the next meeting. They also worked in the group to solve the problem question in their group. For Part of exercises, the students worked in the class without using PhET simulation.

3.2 Students' Understanding

The result of Students' Understanding

The comparison between pretest score and posttest score of the sample in learning Solar System has been analyzed using the average-normalized gain analysis. The result can be found that the average pre-test and post-test between two groups have a different score. The pretest score of control group has achieved an average score of 44.76, while experiment group has achieved an average score of 54.04. For posttest, the score for control group has shown the average score at 68.09, while for the experimental group has shown the average score at 74.76. From the score of average between pretest and posttest from two groups will obtain the average normalized gain value. It is found that the normalized gain between the control group and the experimental group has improvement of students' understanding in learning the solar system. In control group, the average N-gain is 0.42, while average N-gain for experimental group is 0.60. The result from both groups is found that is a significant improvement of students' understanding in learning the concept of Solar system topic. Average N-gain from the experimental group has higher than the control group in a learning activity.

Testing the normality data used SPSS 17. Normality test to find N-gain data obtained has the distribution is normal or not in both two group (control and experimental) as seen in Table 5. In this study, to measure the distribution of data, the method used is Saphiro Wilk. The data is called normal distribution if the value of Shapiro Wilk ≥ the significant value (0.05) (Minium, King, & Bear, 1970). In this study, the normalized data used average N-Gain to determine data of sample has normalized distribution or not. Table 5 shows that the value of the experimental group is 0.037 while the value of control group is 0.262. Therefore, based on the criteria of normality test from the value of **Shapiro-Wilk,** the experimental group has not normalized distribution because the value of **Shapiro-Wilk** is 0.037 ≤ value significant 0.05. In control group has normalized distribution because the value of **Shapiro-Wilk is** 0.262 ≥ value significant 0.05. Because one of the group has not normally distribution population, then the next method will be used is Mann-Whitney.

The Mann-Whitney is the absence of a requirement that the research data should normally distribution and homogeneous. The result from Mann-Whitney test shown in Table 6. For Mann-Whitney test, there are criteria used as a reference for decision hypothesis. The criteria for Mann-Whitney test as follow: If Asymp.Sig. (2-tailed) ≤ probability 0.05, so H_a accepted. If Asymp.Sig. (2-tailed) ≥ probability 0.05, so H_a rejected. Based on to Table 6. the result showed that Asymp.Sig. (2-tailed) is .038. It can be concluded H_a accepted for Mann-Whitney test because of Asymp.Sig. (2-tailed) is 0.038 ≤ probability 0.05. Therefore, it can be said that it is significantly different from the result students' understanding between the control group and experimental group. As a result, it is concluded that experimental group has highly significant improvement in student understanding where they learned Solar System by PhET simulation.

The Improvement of Students' Understanding Cognitive Domain

The improvement of students understanding in cognitive domain divided into six cognitive domains based on Blooms' Taxonomy Revised. In this study, the cognitive domain measured is limited to four cognitive domains spread out in test item. The four cognitive domains that implement into test item are Remembering (C1), Understanding (C2), Applying (C3), and Analyzing (C4). The test item was tested to students in the form pre-tests and post-test. The result of test item in two groups are

Table 5 Result n-gain normality from normality test between control group and experiment group

	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Average N-Gain	Control group	.944	21	.262
	Experiment group	.901	21	.037

Table 6 Result n-gain normality from mann-whitney test

Analysis	N-Gain
Mann-Whitney U	138.000
Asymp. Sig. (2-tailed)	.038

Table 7 Comparison the average of pretest and posttest score between control group and experimental group based on cognitive domain

Cognitive level	Control Group			Experiment Group		
	pretest	posttest	N-Gain	pretest	posttest	N-Gain
Remembering (C1)	33.33	76.19	0.64	44.44	84.12	0.71
Understanding (C2)	38.62	57.67	0.31	51.85	75.66	0.49
Applying (C3)	54.76	80.95	0.57	69.04	92.85	0.76
Analyzing (C4)	56.34	75.39	0.43	57.14	80.15	0.53

shown in Table 7. Based on the table, the data shown that post-test score is higher than pretest score in each level cognitive from both groups. For remembering domain (C1), in protest, the experimental group obtains the score 44.44, while control group has score 33.33. After given treatment and taken data for posttest, the experimental group obtains the score 84.12, while control group has the score 76.19. It can be concluded that in remembering domain (C1), experimental group is a higher score than the control group.

In an understanding domain (C2), the data showed that post-test score has a higher score than protest in both of groups. A pre-test in control group obtains score 38.62, and experimental group obtains score 51.85. After treatment implemented in both of group, so the posttest score in the control group is 57.67, and experimental group is 75.66. It can be concluded that the experimental group is slightly better than the control group after the experimental group given treatment by PhET simulation in Solar System topic. It means that PhET simulation used in the experimental group is better than using PowerPoint slide in control group.

In applying domain (C3), a pretest of control group shows the score 54.76, while pretest of experiment group shows the score 69.04. For the posttest also is same with a pretest that experimentally is higher than the control group. Where the experimental group shows score 92.85 and control group obtains score 80.95. For analyzing domain (C4), same with cognitive domain has explained before that the posttest shows higher score than pretest score. It the same with a domain where pretest score in control group is 56.34, while for experiment group shows the score 57.14. After both of groups given treatment, there is an improvement in the post-test score. In control group achieves the score 75.39 and the experiment group achieves the score 80.15. The post-test experiment group also shows a higher score than the control group.

From the explanation about the comparison in average pretest and post-test scoring from both of two groups, we found that the pretest score of the experimental group has a higher score than the control group. The result of pretest score where the experimental group as not given treatment yet is better than the control group. However, the control group also is better because they score are improved after they have learned Solar System using PowerPoint. The same the control group, the experimental group also achieves a higher score in post-test than pretest. They improve the score after they used PhET simulation in learning Solar System topic.

Based on the result, it is found that four cognitive domains are significant between control and experimental group. All of the cognitive domains are an influence on students' achievement. However, the line graph which slightly significant is an understanding domain (C2). It shows that the value of average N-Gain in experimental is greater than the control group. In Experimental group has a value of average N-Gain is 0.49 while control group has 0.31. It means that PhET simulation was used in the experimental group is influence than using PowerPoint slide in control group.

Three cognitive domains used in evaluating students' understanding have significant value although they are a weaker understanding domain (C2). Even though three domains (remembering, applying, and analyzing) influence in the improvement students' understanding. Because the value of average N-Gain of the experimental group is greater than the control group. Therefore, the PhET simulation is influenced by teaching media to deliver the concept Solar System than powerpoint slide was used in control group.

The Discussion of Students' Understanding and Implementation of PhET Simulation

According to the result of student understanding, the researcher found that there is an improvement in students' understanding of the concept of Solar System. Based on the result Mann Whitney test, there is a significant difference in pretest and post-test score between the control group and experimental group. The pretest and post-test score is measured from normalized gain. In experimental group (0.60) is greater than the control group (0.42).

The finding shows that the quality of experimental group is high, while for the control group is categorized as a medium from the experimental group. Thus, PhET simulation can be used as a teaching media in the learning process because PhET simulation can improve the posttest score of the experimental group. Because of the experimental group have four meetings by using PhET simulation in a learning activity. In the activity class, a student in control group was operated the simulation

Table 8 Comparison Average between experiment and control group in each aspect questionnaire

Aspect of Questionnaire	Statement	Number of statement	Control Group		Experiment Group	
			Average	Percentage (%)	Average	Percentage (%)
Computer Attitude Questionnaire	Positive	1, 2, 3, and 4	2.69	63.25	2.69	63.25
	Negative	5, 6, and 7	2.37		2.37	
Science Motivation Questionnaire	Positive	8, 9, 10, and 13	2.94	73.00	2.94	73.00
	Negative	11, 12, and 14	2.90		2.90	
Determination Theory Perspective questionnaire	Positive	15, 17, and 18	2.39	62.00	2.39	62.00
	Negative	16, 19, and 20	2.57		2.57	

process for the topic Solar System which has entitled *"Gravity and Orbits"*. The teacher gave the problem to students in the worksheet. They analyzed the problem and solve it the worksheet by used PhET simulation. In the worksheet paper, students understand the law gravity. Because of PhET simulation is a simulated animation to prove the gravity law. They can change the variable such as mass, velocity, and gravity force. One by one, the object has changed and students analyzed the object, which has changed by them. They did it seriously and has curious to the variable object. They always answer the question asked by the teacher for giving an explanation if they did not understand it during the learning process. The teacher always guided students when students did in the worksheet. Nevertheless, for the simulation that used is not an accurate measurement. Because there is no quantity number of the variable object. Students only change variable object by a ruler provided in the simulation. A ruler changes the variable objects are only more or less of mass, velocity, or it can be on or off the gravity force. Even though PhET simulations are interested in experimental students, because it is an interactive multimedia. They can imagine how the planet performs an orbit, how the mass effects of the rotation of the planet, and others which have abstractly idea for a human. Because the planetary motion cannot be seen with naked eyes directly. Students only receive the information from the news media.

PhET simulation is actually familiar for both groups because the PhET simulation has used by another science teacher in the topic "Wave". They have learned the concept of the wave using PhET simulation previously. However, the teacher only gave an introduction the concept without deeper analyze to Wave concept. It is in line with the result level cognitive for both groups. From the result, remembering domain (C2) shows higher N-gain score than another cognitive level for both two groups. It shows that the PhET simulation that was used will help to improve the students cognitive in the remembering domain. Although another cognitive domain such as remembering (C1), applying (C3), and analyzing (C4) is significantly different between the control group and experiment group, PhET simulation is influenced in teaching-learning process to students' understanding.

In learning of effect rotation and revolution for the experimental group, there was a problem in a learning activity. There was a meeting among students to vote selection for OSIS 2017-2018. Most students in the experimental group, they were to be committee or candidate. Therefore, students did not follow class activity effectively. They do not understand what the content that delivered by the researcher. For the posttest also, they have another subject test at the same time with the posttest of the researcher. They learned about the topic that they did not follow at that time. They also ask the researcher to review again them before they take posttest. The posttest is postponed to next meeting on a science subject.

3.3 Students' Motivation

The second variable analyzed is student motivation. The data obtained by questionnaire of motivation. The questionnaire developed by the researcher is adapted from three design questionnaire, they are Computer Attitude Questionnaire (CAQ) by (Knezek & Christensen, 1996), Science Motivation Questionnaire by (Glynn & Kobala, 2006), and Determination Theory Perspective questionnaire (Deci, Eghrari, Patrick,, & Leone, 1994). The result is shown in Table 8. Based on Table 8, we found that the scoring average between experiment group and control group has a different score. The higher score is experiment group. For computer attitude aspect, it describes the using Computer-based learning in the delivering material or utilizing the computer for student activities. In experiment group, the score is 71.62% and control group is 63.25%. For science content, is describes how students learn in the Solar system topic. In the score, the control group is higher than experiment group. The score control group is 73% and experiment group is 79.12. The determination self-aspect describes using PhET as teaching media in learning Solar system topic. The experiment group is higher score about 69.87% than control group is about 62%.

Generally, in each aspect condition students motivated enough. Nevertheless, there are slightly different between with PhET simulation and without using simulation. For control group who did not use PhET simulation in learning Solar system topic, they are the same condition between pre-test and post-test. For computer attitude aspect

between pre-test and post-test is a similar condition. In the experiment class, after using the PhET simulation in learning the Solar system, they slightly increase motivated, so the score is higher than the control group. They have a different score, where the experiment group is higher than the control group. The experiment group, they used a computer to operate the PhET simulation, and they are interested in computer-based learning. For several meetings, they used computer-based learning as media tool in a learning activity, such as power point presentation. The researcher used power point presentation as media learning in delivering the content.

For Science Motivation aspect, the control group has same the condition before and after learning the Solar system without using PhET simulation. While experiment group, they are slightly increasing condition before and after using PhET simulation as media learning for Solar system topic. The last aspect is the self-perspective determination, where the student has an opinion about using PhET simulation as media teaching media in learning Solar system topic. Based on the data result above, for the control group, they did not use PhET simulation as media learning. The researcher uses Powerpoint presentation or another media teaching to deliver the materials. PhET simulation is only treated in the experiment group. Therefore, it will result in the different perspective between the control group and the experiment group about PhET simulation. As the result, they are enough motivated in learning Solar system topic. Nevertheless, if we compare to the experimental group, the control group still showed low motivation than experiment group. Because they were treated in the same condition of pretest as a posttest. While the experimental group, they slightly perform different condition between pretest and posttest. They are motivated when they are learning Solar system using PhET simulation.

3.4 Correlation of Students Understanding and Motivation in using PhET simulation as Teaching Media for Solar system topic.

Teaching material comprehension is very important in the learning process with the support good learning motivation. To investigate the correlation between students' understanding and motivation, Table 9 was analyzed using Pearson test. Based on Table 9, it is found that there are some students who attain a high score in objective test and questionnaire. From the data, the result is obtained during did research, the researcher correlated between the average of objective test and questionnaire. The objective test is used to measure the student understanding after students have learned all material. The test has been delivered by the researcher using PhET simulation, while questionnaire to measure their perspective about the aspect in learning the content of the topic, as utilizing the computer in the learning process, a science lesson, and utilizing PhET simulation as a teaching media in the learning process.

Table 9 Correlation of students understanding and motivation in learning Solar system using PhET simulation

Aspects	Analysis	understanding	motivation
Understanding	Pearson Correlation	1	.440*
	Sig. (2-tailed)		.046
	N	21	21
Motivation	Pearson Correlation	.440*	1
	Sig. (2-tailed)	.046	
	N	21	21

The result shows that the correlation between students' understanding and motivation is correlated each other. The score correlation is 0.46; the category including 0.25-0.5 is moderate based on (Sarwono, 2006). It can be concluded that there is a correlation between students understanding and motivation using PhET simulation in the learning Solar system. To find a student who achieves a higher understanding of higher motivation, it will show in Figure 3.

Figure 3 shows that there is a student who achieves a high score in learning the Solar system, they have a higher motivation to use PhET simulation. The result of highest achievement will correlate to motivation score. For example, the students are F06, she has a high average of students understanding score, but they also correlate with highest of motivation score. For M07 also has correlated with score motivation and understanding. The researcher found there are six students who correlate with score motivation and understanding. All of the students have not higher score in cognitive achievement has higher motivation. There some students has moderate achievement but they have high motivation, for example,

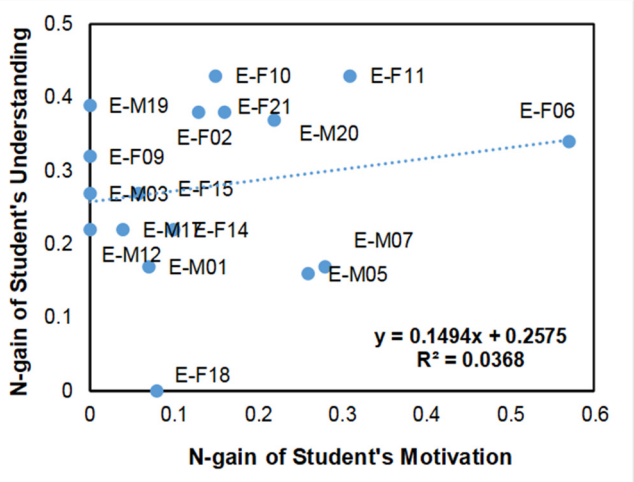

Figure 3 Correlation of students understanding and motivation in learning Solar system using PhET simulation

F15 and M19. They have interest in science learning so they motivation will be high.

According to (Mutoharo et al., 2015), there is a positive correlation if the motivation in science learning is increasingly better than the understanding concept of science also increases. Some students increase their score in posttest compared to pretest, they also increase the score motivation after using PhET simulation. This finding also supports the statement by Bell & Smetana (2015), as with any other educational tool, computer simulations are tools to support learning. Computer simulation as media learning which has a role in increasing student motivation and aspect in learning activity becomes more interference and quality of learning (Nurohmah, 2015).

4. CONCLUSION

Based on the result and discussion of the data that has been explained it before about PhET simulation as teaching media in learning Solar System topic was placed in 8th grade is one of a private school in Padalarang, it can be concluded that the implementation PhET simulation conducted in seven meetings, which are pretest-posttest and learning activity. The use PhET in the learning activities was done well and it can be an improvement for the experimental group. Students have utilized PhET simulation to learn the Solar system. According to the students' understanding on the concept Solar System, especially in orbits and gravity of the planet, it is showed that experimental group has a higher score (<g> = 0.45) than the control group (<g>=0.42). Based on the data obtained in this study, there is a significant improvement in students understanding between experimental group and control group. Therefore, the hypothesis H_a is accepted in this study. The result shows the significant value. It can be concluded H_a accepted because Asymp. Sig. (2-tailed) is 0.038 ≤ probability 0.05.

Student responses about PhET simulation as a teaching media in the learning process show a good response. They are very enthusiastic when they used PhET Simulation about the Solar system. Because they can more explore the abstract concept and they can solve the problem from the worksheet that given to them. PhETsimulation is very interactive media. Moreover, there is a significant correlation between students' understanding and motivation. The score correlation is 0.46 categorized as moderate. Thus, the higher the students' motivation, the higher the student's achievement on learning the Solar system.

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