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The Effect of PhET Simulation in Science Learning of Static Fluid Pressure Topics towards Students' Creative Thinking Skill

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ABSTRACT

This study aims to see is there a significant effect of the use of PhET simulations in science learning of static liquid pressure topics towards creative thinking skill of middle school students. This research was conducted at SMPIT Al-Ghozali Jember in 8th grade of C class and D class where each class consisted of 21 female students. The design of this research is *Control Group Pretest-Posttest* in which the learning in experimental class uses the PhET simulation while in control class uses the experimental video. The results of *Wilcoxon Signed-Rank Test* on students' creative thinking skill test scores are differed significantly both in the experimental class and the control class. The results of *Mann-Whitney* test are the students' student worksheets in the experimental class differed significantly from the control class. It can be concluded that there is a significant effect of the use of PhET simulations in this study.

INTRODUCTION

In the last researches, often stated that together with the development of 21st century, the education field also changed dynamically to meet the need of better qualities human resources. Those caused the 21st century skill should be integrated especially in science curriculum which one of them is creative thinking skill [1], [5]. Student-centered learning known to be help emerge creative thinking skill in class. Concepts within the Nature of Science are built by scientific process and attitude so that when learning science, the condition that can help students understand and construct the concept need to be provided [4], [5].

Static fluid pressure is one of the topics contained in the range of material science lessons. Concepts that are contained in the topic are very complex so it is classified as a

difficult matter for students to understand. To understand the concepts of liquid pressure, students still find some difficulties in constructing knowledge from basic concepts so that the direction of the matter will be easier for students to understand if it is conveyed through learning media. The use of learning media can represent abstract ideas and concepts in static fluid pressure topics [6], [7].

One of many multimedia namely PhET (Physics Education Technology) Simulation known could be used as a learning media to foster students' creativity. Through the simulation that based on research of real-world phenomena, students are offered with concept exploration by interactive fiture [8]. Several studies on the use of PhET simulations in learning material on liquid pressure include correction of student misconceptions [9], [10], [11], improve the understanding of concepts and learning motivation of students [12], improve learning outcomes [13], improve higher-order thinking skills where PhET is combined with the PBL model [14], and improve creative thinking skills where PhET is combined with the HOTVL model [15].

Based on these descriptions, it can be seen that research in looking for the effect of PhET simulation as a science learning medium on students' creative thinking skills still needs to be done. Therefore, this study aims to see whether there is an effect of the use of PhET simulation media in science learning with static fluid pressure on the creative thinking skills of junior high school students.

Science learning is a learning that is in accordance with the nature of science learning, which is process-oriented and achievement based on a scientific attitude. To support this, science learning should be carried out by scientific inquiry so that students can improve their ability to think, work and behave scientifically, and are well-skilled in communication [16]. Science learning at the junior high school level is an integrated science learning. Content in science subjects is a combination of concepts from the fields of biology, physics, chemistry, and earth and space sciences [17]. Integrated science learning is a learning approach that can help students get used to actively exploring, elaborating, confirming, and communicating the results of their knowledge construction [18].

Multimedia is a combination of two or more integrated media formats such as graphics, text, animation, and video that forms a structure of information into a computer system [19]. The newer types are equipped with additional features such as interactive multimedia. Interactive multimedia is a medium that brings together elements of text combination, graphics, sound and video which provides flexibility of control to the user. Interactive multimedia simulation type is generally used in real models of conditions that are contained in a system. One of interactive multimedia is laboratory experiment simulations which were developed to avoid unexpected impacts from experiments in real laboratories [20].

PhET (*Physics Education Technology*) is an interactive simulation provided free of charge which was developed by the University of Colorado Boulder. PhET simulation provides a simulation based on physical phenomena based on research results so that it is relevant to the existing concepts and facts [21]. PhET interactive simulation provides a series of more than 160 simulations for science and math learning. Each simulation available on the website http://phet.colorado.edu is free, accessible *online* and *offline* via download, and is openly licensed. The material contained in the simulation has been developed to make it more supportive for teachers' use in learning [22].

The virtual stimulus provided by the PhET simulation initiates the curiosity of students to construct concepts and apply them through the manipulation of variables that can affect the experiment results [23]. An interactive simulation on the topic of static fluid pressure contained in PhET simulation entitled *Fluid Pressure and Flow* can be used to create a more effective learning environment [24]. In Science learning process of the static fluid pressure matter uses the PhET simulation, students are expected to be able to creatively modify the various components available in the simulation to achieve learning outcomes. Here are some display images in the PhET simulation used for learning science on static fluid pressure topics.

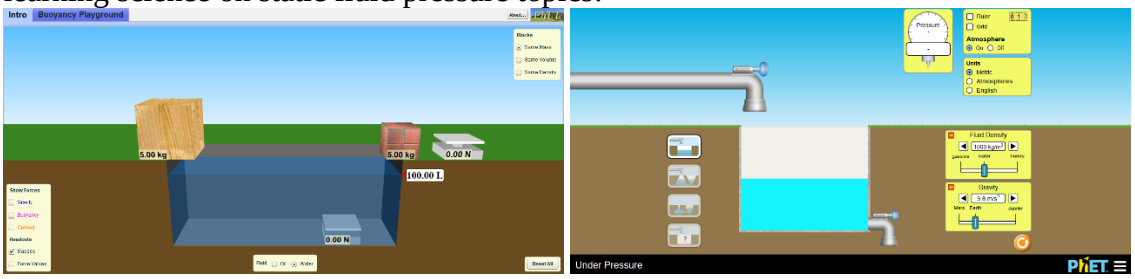

Figure 1. Display of (a) PhET "Under Pressure" and (b) "Buoyancy" Simulations

PhET simulation with the theme "*Under Pressure*" implements the use of vessels that can be modified into three types, namely closed vessels, related vessels, and hydraulic pump models. Therefore, in addition to the concept of hydrostatic pressure, PhET simulation with the theme "*Under Pressure*" can also be used for the concept of Pascal's Law. PhET simulation with the theme "*Buoyancy*" presents two experiments, namely "*Intro*" with a modification of two types of liquids but without mass modification and "*Buoyancy Playground*" with more complete modifications covering mass, volume and type of load, as well as five kinds of liquids.

The ability to think creatively is the ability to reveal new relationships, see a problem from various points of view, and form a new blend of concepts that have been mastered [25]. According to Torrance (1996), creative thinking skill consists of four abilities that can be taught and measured, namely fluency, the ability to generate a number of ideas; Flexibility, the ability to generate different types of ideas; Originality, the ability to generate one idea among various ideas; and Elaboration, the ability to add details or expand on ideas [26].

METHODOLOGY

This research is a quasi experimental study conducted by providing treatment to determine the effect of using PhET simulation media in science learning with static fluid pressure on students' creative thinking skills in the experimental class. The expected effect of this study is that students' creative thinking skills after treatment (post-test) differ significantly from those before treatment (pre-test). The design used in this study was the Control Group Pretest-Posttest Design which provided different treatment between the experimental class and the control class as well as tests before and after treatment [27]. This design can be described in the following table.

Table 1. Research Design of Control Group Pretest-Posttest

E	T_1e	X	T_2e
K	T_1p		T_2p

(Source: Sanjaya, 2013)

Where:
E: Experimental class
K: Control Class
X: Treatment
T_1e: pre-test of experimental class
T_1p: pre-test of control class
T_2e: post-test of experimental class
T_2p: post-test of control class

. This research was carried out at SMPIT Al-Ghozali Jember with the research subjects of 8th grade of odd semester academic year 2020/2021. Determination of the research location using purposive sampling area technique with several considerations, namely the availability of facilities and infrastructure needed in the research, the willingness of schools to be used as a place to carry out research, and school cooperation for the facileness of the research process. The population used in this study were all class of 8th grade students of SMPIT Al-Ghozali Jember, 2020/2021 academic year. Class of 8th grade at SMPIT Al-Ghozali consists of 2 male classes and 3 female classes. The sample in this study was taken of two classes from all classes of 8th grade students of SMPIT Al-Ghozali Jember, there are one class as the experimental class and one class as the control class. Before determining the research sample, a homogeneity test was carried out on the data from the daily test results of the previous subject to find out whether the population had a homogeneous ability or not. Because the data tested was homogeneous, the sampling was done by using the cluster random sampling technique.

The data needed in this study relates to the scores of students' creative thinking skill obtained through test results and student worksheets. The test used is a written essay test with an open-ended question type consisting of 4 items in which each indicator of creative thinking skill is represented by 1 question. Student worksheets are the results of student experiments with PhET simulations which are done in groups. The scores of the students' exam results were then categorized into the criteria for creative thinking skill, namely very good (85-100), good (69-84), moderate (53-68), less (37-52), and very less (≤36) [28].

Statistical tests were carried out using the SPSS version 20 program through 2-tailed hypothesis testing at a significance level of 25% or 0,025. To test the hypothesis of the effect of PhET simulation media on static fluid pressure topics towards creative thinking skills, the nonparametric Wilcoxon Signed Rank test was used to verify the creative thinking skill test results while the Mann-Whitney test used to verify students' worksheet scores. The statistical test used nonparametric because the data on test scores and students' worksheets were not normally distributed after being tested by the Saphiro-Wilk test. The hypothesis offered in this research is the null hypothesis (H0) and the alternative hypothesis (Ha). The null hypothesis (H0) is that the average value of the students' creative thinking skill before and after treatment is the same, while the alternative hypothesis (Ha) is the average value of the students' creative thinking skill before and after treatment is different. The criteria for testing the hypothesis is if the 2-tailed significance value ≤ 0.025 then the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted, but if the 2-tailed significance value is more than 0.025 then the null hypothesis (H_0) is accepted and the alternative hypothesis (H_a) is rejected.

RESULTS AND DISCUSSION

Data analysis was carried out to answer the problem posed in the study, namely whether there was a significant effect of the use of PhET simulation media on the creative thinking skill of junior high school students in learning science on static fluid pressure topics. Data from students' test of creative thinking skill analyzed through average comparison test with Wilcoxon Signed Rank test while the results of students' worksheet were tested with the Mann-Whitney test.

Table 2. Results of Wilcoxon Signed Rank Test

Score	Class	Sig. (2-tailed)
Creative thinking skill test	experimental	0,001
	control	0,009

Based on Table 2, it can be seen that the significance value of the Wilcoxon Signed Rank test in the experimental and control classes is 0.001 and 0.009, respectively. With a significance level of 0.025 (2.5%), the significance value of the two classes based on the test is less than 0.025 (p-value <0.025) so that both the experimental class and the control class have significant differences between the pre-test and post-test results of their creative thinking skill. The difference and increase of mean of both the pre-test and post-test of the experimental and control classes are shown in Table 3. which then is depicted in graphical form in Figure 2. The difference of mean score for each indicator of the creative thinking skill can be seen in Figure 3. which is displayed in the form of a bar graph, while the differences of creative thinking skills' categories between the experimental and control classes are shown in the graph in Figure 4. The test given consists of 4 questions. The score of the test was given in the range of 1-4 points for each question so that the students' test score will be in te range between 1-16 points. The score obtained then conversed to the range score between 1-100 points for categorizing the students' creative thinking skill.

Table 3. Mean Score of Pre-Test and Post-Test Results

Class	N	Pre-test		Post-test		Gain in Mean
		Mean	SD	Mean	SD	
experimental	21	3,905	0,930	5,19	2,118	1,285
control	21	3,619	0,650	4,5	1,084	0,881

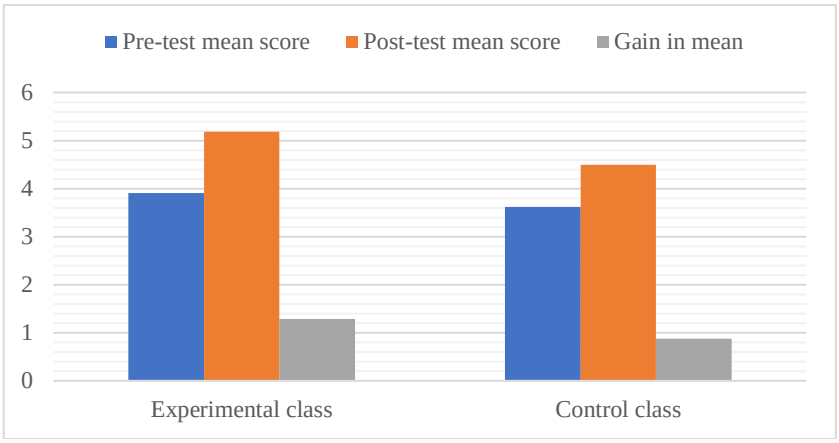

Figure 2. Mean Score and Gain in Mean of Experimental and Control Classes

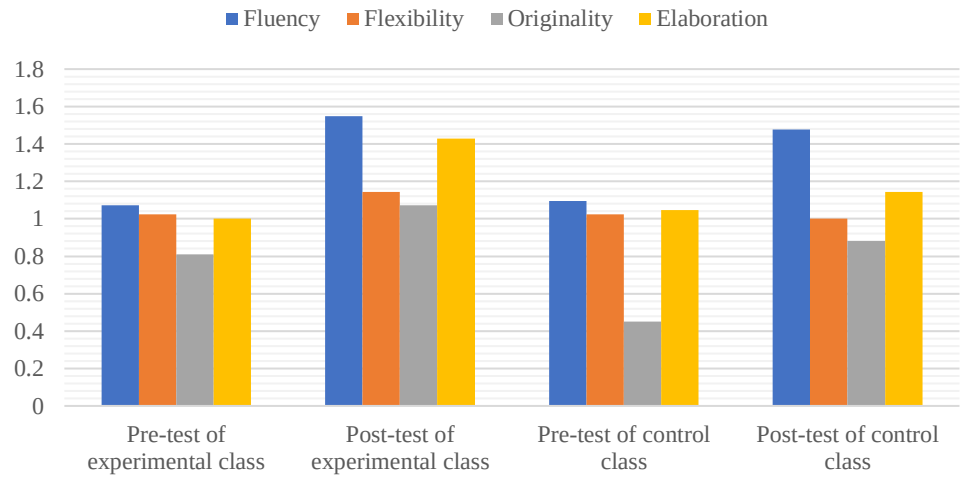

Figure 3. Mean Score of Creative Thinking Skill Indicators

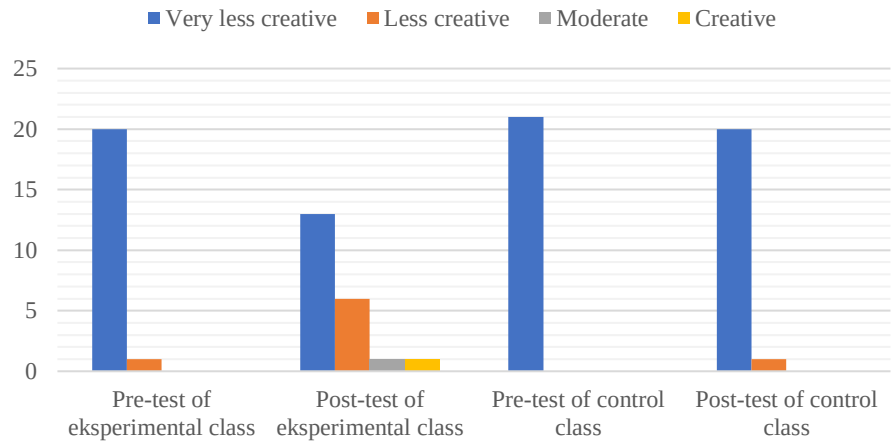

Figure 4. Categories of Creative Thinking Skill

Mann-Whitney test *was* carried out to see the differences between two unrelated samples based on a nonparametric test. Because the data on students' worksheets of creative thinking skill were not normally distributed, the test then was carried out using Mann-Whitney test which is shown in Table 4 below. The score of students' worksheets

was given in the range of 1-4 points for each work. The final results were the average score of the whole score obtained.

Table 4. Results of Mann-Whitney Test

Score of	*Mann-Whitney Test*		
	Mann-Whitney U	Z	Sig. (2-tailed)
Students' worksheet	100,5	-3,082	0,002

Based on the data in Table 4. above, it can be seen that the students' worksheets of creative thinking skill have a significance of 0.002 with a significance level used is 0.025 (2.5%). Because the significance value is greater than 0.025 (p-value > 0.025), it can be concluded that there are significant differences in the student's worksheets of creative thinking skill both in the experimental and control class.

A significant difference between the means of the variables from the interrelated samples can be found through the related-sample test. Two types of tests that are commonly used are the paired-sample t-test for the parametric test and the Wilcoxon signed rank test for the nonparametric test [29]. Data on students' creative thinking abilities were tested with the *Wilcoxon signed rank test* because the data did not meet the requirements for a normal distribution for the parametric type test so they were tested using the nonparametric test. Based on the results of the Wilcoxon signed rank test in Table 2. it is known that the creative thinking skill of students in the experimental class differ significantly from before and after treatment in the learning with PhET simulation media. In Table 2, it can also be seen that the results of students' creative thinking skills tests in the control class that using experimental video learning media also have significant differences from before and after being given treatment. Because the experimental class and the control class gave significant differences, then the data is presented in Table 3. to compare the difference of mean in the test results of students' creative thinking skills both in experimental and control classes.

Although in the two classes were found the significant differences of the test results from before and after treatment, the 2-tailed significance value in the class that used PhET simulation media had a much smaller value than 0.025 (25%) compared to the class that learned using experimental video media. The mean of creative thinking skill test results was shown in Table 3.and illustrated in graphical form in Figure 2. In Table 3, it is known that the increase of mean in students' creative thinking skill test score in the experimental class is 1,285 while in the control class is 0,881. Based on the graph in Figure 2. it can be seen that the increase of mean in the post-test score of the experimental class is higher than the control class. Similar results have been found by [30], in which the results of the creative thinking skill test of students in a class that carried out learning with the PhET simulation of static fluid pressure topics had a higher mean score than the class that did the learning without the PhET simulation media.

Based on the graph in Figure 3. we can see that the indicator of fluency has the highest value and increase among other indicators. These results are relevant to previous research conducted by Habibi *et al*., [31], which in learning physics using PhET simulation, the gain score of students' creative thinking skill on fluency indicator has a highest increase among three other indicators namely flexibility, novelty, and elaboration. The fluency indicator represents the ability of students to understand and show the relationship between concepts as a solution to a given problem so that it greatly affects the further development of the creative process [32], [31].

The increase in mean score of students 'creative thinking skill test in the experimental class which was higher than the control class can be seen further in Figure 4. that shows a graph of the differences in the change of students' creative thinking skill categories. In the experimental class, the students' creative thinking skill before learning with PhET simulation was categorized as very low, as many as 20 students out of a total of 21 students and 1 other student was categorized as less creative. After learning with PhET simulation, the students' creative thinking categories in the experimental class changed to 13 students in the very less creative category, while the less creative category became 3 students, while the moderate and good category was 1 student. In the control class, before and after learning with experimental video media gave the changes that were not very meaningful where 21 students before learning were categorized as very less creative and after learning, 20 students were categorized as very low and 1 other student was categorized as less creative.

The ability to think creatively is the ability to come up with a new solution through the process of disclosing new relationships, reviewing problems from various points of view, and forming new combinations of concepts that have been mastered [25]. In a more specific way, the creative thinking skill of secondary school students refers to the ability to productively generate, evaluate and improve ideas so that they can produce new and effective solutions, increase knowledge, and express imagination. Creative thinking skills can be emerged and developed through learning activities in the classroom [33].

The development of creative thinking skills is supported by various conditions that can be created in the classroom, like stimulating students with attractive problems from everyday life phenomena, supporting students to have a high curiosity about various possible solutions that can be used, facilitating discussion activities to construct students' knowledge, and facilitating students to work in groups [26], [34]. From the descriptions above can be known that the students' creative thinking skill both in experimental and control classes resulted in significantly different. This is because in both classes, the learning process is carried out through group work and discussion activities.

Based on Table 4, which shows the results of Mann-Whitney test for the result score of students' worksheets of creative thinking skills, it can be seen that the mean score in the experimental class differs significantly from the control class. This means that the use of PhET simulation media for static fluid pressure topics has a significant effect on the students' worksheet score of creative thinking skill. This result is relevant to the findings of Bandoy *et al*., [35] which reported that PhET simulation for static fluids topics can be used as a learning media to hone students' creative work through interactive features that provided in the simulation. Experiments that are carried out using PhET simulations can be repeated according to user needs so it can help reduce the fear of trying and the fear of failure. With the advantages of PhET simulation, knowledge construction can be carried out in the learning process so that it will positively impact the learning activities.

CONCLUSION

There is a significant effect of the use of PhET simulation media towards the creative thinking skills of junior high school students in science learning on static fluid pressure topics. This significant effect is known from the significant difference between the results of students' creative thinking skill test from before and after obtaining

science learning using PhET simulation. This significant effect is also indicated by a significant difference in the student's creative thinking skill worksheet score between the class that conducts science learning with PhET simulation media and the class that conducts science learning using experimental video media.

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