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A meta-analysis of the effects of using PhET interactive simulations on student's worksheets toward senior high school students learning result of physics

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Abstract. The purpose of this study was to analyze the effect of the use of PhET Interactive Simulations student worksheets on students learning outcomes. The method used is the meta-analysis method. Meta-analysis is a technique used to summarize a variety of quantitative research results by finding the value of effect size using a sample of 10 articles in national journals. The results showed average effect size of 1, 117 with a standard deviation of 181,1. The resulting effect size is categorized as medium. Means that the influence of the use of PhET Interactive Simulations student worksheets can improve student learning outcomes by 32,73%.

1. Introduction

Education is a process to develop the potential of human resources to cange the quality of each individual towards a better direction. The quality of education needs to be improved to be able to compete at the national and international levels, especially in the face of globalization. Through education, knowledge will increase and insight will broaden, so that a personal figure who is more knowledgeable, sensible, and thinks rationally.

Learning is essentially the conscious effort of a teacher in order to achieve the goals expected to learn students and direct student interaction with other learning resources. Science or Natural Sciences is a systematic collection of theories, its application is generally limited to two natural phenomena, born and developed through scientific methods.

The learning process, especially physics learning must be held interactively, inspiratively, fun, challenging, integrated, and can motivate students to actively participate and provide sufficient space for the development of student creativity. But the problems faced in learning physics in the 21st century are generally not only limited to the ability to master the concepts of physics, but also require students to develop the ability to think creatively that allows students to analyze the results of their thinking in making choices and draw conclusions intelligently (Kurniawati 2014; Festiyed, 2019).

Learning objectives are something that you want to achieve after participating in teaching and learning activities. In every lesson teachers are often the center of learning (teacher centered) and students are only the recipient objects. Besides that, the use of the current learning system where students are only given knowledge verbally (lectures) so that students receive knowledge in the abstract (only imagine) without experiencing it themselves.



The approaches and methods used seem less varied, usually only rely on the form of lectures, not yet using various tools and ways to inspire (Aljufri, Festiyed dan Syakbaniah, 2009). The teacher also has not optimized the environment as a learning resource to make learning interesting, fun, and suitable for students. The concept of such learning activities is no longer relevant to the demands and challenges of education in the era globalization (Festiyed, 2008)

The education function as outlined in the 2013 Curriculum demands active and creative learners. Various efforts have been made by the government to improve the quality of education, including the improvement of the curriculum from the Education Unit Level Curriculum to the 2013 Curriculum. Various elements of the old curriculum were developed to get a better curriculum, one of them in the learning process. The standard process that initially focused on exploration, elaboration, and confirmation, was refined with the 2013 curriculum Observing, Questioning, Experimenting, Associating, and Networking through the use of various learning resources. Where the 2013 curriculum relies on the form and learning activities in the classroom (Festiyed, 2015).

In order to achieve these learning objectives, it is necessary to have interesting student worksheets in the implementation of learning to optimize the learning process with the more dominant ones involving students, namely by using PhEt Interactive Simulations aided Student Worksheets. This student worksheet emphasizes the specifics of students to solve problems from various sources through scientific means and the teacher guides students in determining the process and identification of temporary solutions to problems so as to make students more active. Student Worksheets (LKPD) are appropriate tools to guide students in carrying out activities.

PhET is an interactive simulation of free physical research phenomena. PhET is made and arranged based on the laws of science that are adjusted. PhET is able to facilitate educators to conduct practicum virtually.

Based on the description, then this paper aims to analyze the effect of the use of PhEt Interactive Simulations Students Worksheets on students' physics learning outcomes in terms of learning material, and the media used. Therefore, The author is interested in mapping the results of these studies through meta-analysis. Meta-analysis is a technique used to summarize the findings of several or more studies with the aim of combining, reviewing and summarizing previous research. In addition, by using meta-analysis various questions can be investigated based on data that has been found from the results of previous studies that have been published and one of the conditions needed in conducting meta-analysis is the study of similar research results (Sriawan & Utami, 2015); (Nieuwenstein et al., 2015); (Paldam, 2015).

The meta-analysis states the results of the study findings with effect size (ES). According to Sutrisno, dkk (2007), This method aims to answer questions concerning the problem of differences between the experimental group and the comparison group if based on the results of research that continues to grow from year to year. According to Jamie (2004: 2), the basic purpose of the meta-analysis is to provide a methodological similarity to a literature review needed from an experimental study.

Research on the influence of the use of PhEt Interactive Simulation students' worksheets on high school physics learning outcomes has been carried out. There are many models of student worksheets used in the study. For this reason, it is necessary to carry out a meta-analysis to obtain a unified understanding or general conclusion from similar research results.

2. Research Methods

This research uses a meta-analysis method. Meta analysis is a quantitative analysis and uses a considerable amount of data and applies statistical methods by practicing it in organizing a number of information derived from a large sample whose function is to complement other purposes for organizing and extracting as much information as possible from the data obtained, as well as a The technique is intended to re-analyze research results that are processed statistically based on primary data collection (Glass, 1976); Sutjipto (1995:30); (Bloom et al., 2009); (Hunter, Jensen, & Rodgers, 2014).

This type of research is a survey research. Survey research is one method of research that aims to obtain a general picture related to the characteristics of a population that is described through a sample.

Through the collection of these characteristics the researcher tries to find a match from the results of previous studies with the results of the current study. With reference to the initial purpose of meta-analysis research, then this study can be used to show the presence or absence of a comparison on the effect size.

The influence of the use of PhET Interactive Simulations of Student Worksheets on student learning outcomes is done by calculating Cohen's d using the Effect Size formula from Cohen's d as follows:

$$d = \frac{X_E - X_c}{SD} \quad (1)$$

Description : d = value of effect size
 X_E = the average value of the experimental class
 X_k = average value of control
 Sd = combined standard deviation

Look for d values using a formula:

$$sanderdeviasigabungan = \sqrt{\frac{(n_1 - 1)sd_1^2 + (n_2 - 1)sd_2^2}{n_1 + n_2}} \quad (2)$$

Sd = combined standard deviation
 n_1 = the number of students in the experimental class
 n_2 = the number of students control class
 Sd_1^2 = standard deviation of the experimental class
 Sd_2^2 = control class deviation standard

This meta-analysis study used a sample of 10 articles in national journals about the influence of the use of PhET Interactive Simulations of Student Worksheets. The population in this study are national journals that discuss the effect of the use of PhEt Interactive Simulation Assisted Student Worksheets for high school physics learning outcomes. The research sample was taken using Purposive Sampling technique. This is because the data or information to be obtained from the sample is determined based on its suitability with the theme of this study. Analysis of the data used is the analysis of quantitative data with percentages.

3. Results and Discussion

3.1 Results

Research on the influence of PhET Interactive Simulations of Student Worksheets on the learning outcomes of students obtained were as many as 10 studies. The studies were obtained from various sources, namely: articles (research results) in research journals and research reports. In general, the data is obtained by downloading from the internet. Based on a review of 10 studies the following data can be generated in table 1:

Table 1. Category effect sizes of national journals on the effect of learning outcomes

No	Journal Code	Effect Size	Category
1	PA	2,7	High
2	UR	2,68	
3	YD	2,65	
4	EY	2,54	
5	AM	2,46	
6	TH	1,67	High Enough
7	RK	1,34	
8	MN	0,65	Low
9	CC	0,52	
10	AR	0,12	
Amount effect size		17.33	

Average effect size	1.733
Standard Deviation	181.1

In table 1 the effect size category on the effect of learning outcomes was carried out on ten national journal samples in which three categories were obtained, namely five in the high category, two in the medium category and three in the low category. The effect size category on the effect of learning outcomes is obtained by calculating the average effect size of 1.733. This means that the influence of the use of PhET Interactive Simulations Students' Worksheets can improve student learning outcomes by 32.73%. The resulting effect size is categorized as medium.

3.2 Discussions

Student Worksheets are supporting learning resources that can improve students' understanding of the material that must be mastered (Senam, 2010). Student Worksheets are a tool to convey messages to students that are used by teachers in conveying learning material and making time effective, and will create interactions between teachers and students in the learning process.

Meanwhile, in learning the worksheets of students have a greater influence than other media, which means that the worksheets of students are very effective in improving student learning outcomes Physics. For teachers the function of student worksheets is to determine learners can learn forward according to their respective speed and subject matter can be designed in such a way as to be able to meet the needs of students, both fast and slow reading and understanding. This is a logical thing, because in learning, student worksheets begin with the provision of problems related to the real world, students then actively formulate problems and identify their knowledge, learn and relate material to problems, and ultimately make solutions from problem given. So that problem solving skills in learning by using student worksheets have a positive impact on student learning outcomes.

In table 1 the effect size category on the effect of learning outcomes was carried out on 10 national journal samples in which three categories were obtained, namely three in the high category, 3 in the medium category and four journals in the low category. The effect size category on the effect of learning outcomes obtained by the calculation of the average effect size is 1.117, the standard deviation is 181.1. This means that the influence of the use of PhET Interactive Simulations student worksheets can improve student learning outcomes by 32.73%. The resulting effect size is categorized as medium. Table 1 about effect size proves that the student worksheet can have a considerable influence on student learning outcomes. This is shown from the effect size values that vary from ten national journals. One example is the first data which has a sizeable effect size value, reaching 2.7.

4. Conclusion

Based on the results of the meta-analysis that has been carried out, the following conclusions are made (1) Media subject that is used, learning is more effective when accompanied by student worksheets, because the function of the student worksheets is to determine learners can learn forward according to their respective speeds and subject matter can be designed so that they are able to meet the needs of students, both fast and slow to read and understand (2) The average effect size of the effect of the use of PhET Interactive Simulations aids on student worksheets in improving high school physics learning outcomes is 1.733. That means that the application of students' worksheets contributed 32.73% in improving high school physics learning outcomes. (3) Student worksheets that produce the most influence among the 10 journals, namely Student Assisted Worksheets with PhET Interactive Simulations on student learning outcomes.

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