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META-ANALYSIS OF THE INFLUENCE OF ICT BASED PHYSICS LEARNING MEDIA ON THE LEARNING OUTCOMES OF SENIOR HIGH SCHOOL STUDENTS

Nadilla Rahmi Fitri[1], Renol Afrizon[1]*, Hidayati[1], Hufri[1]

[1] *Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*

Corresponding author. Email:afrizon@fmipa.unp.ac.id

ABSTRACT

In the 21st century, information and communication technology has developed rapidly. Changes in the learning system to be student-centered. One of the principles of the 2013 curriculum is that students learn from various learning sources. Learning resources can be in the form of print media or electronic media. When studying, teachers rarely connect physics with everyday life, whereas nowadays, the wording many learning media that can explain physics in everyday life. Research on physics learning media has done a lot. This study has a purpose, namely to see the impact of ICT-based physics learning media on senior high school student learning outcomes. The research method is meta-analysis. Articles published in 2011-2021. The article consisted of 17 national articles and three international articles that met the predetermined criteria to be processed to calculate the effect size. Effect size is calculated based on four categories, namely grade level, ICT-based learning media, learning material units and online/offline ICT-based media. The research results obtained (1) ICT-based learning media gave the highest effect in class XI, namely 1,38. (2) ICT-based learning media gives the highest effect on Video media, which is 2,22. (3) the learning material units gives the highest effect on Mechanics material unit, which is 1,73. (4) online/offline ICT-based media have the highest effect on online media, namely 1,26. Therefore, ICT-based physics learning media has a good effect on student learning outcomes.

Keywords: *ICT-Based Media; Learning Outcomes; Meta-Analysis*

I. INTRODUCTION

In the 21st century, information and communication technology has developed rapidly. Technological advances have also entered the field of education. The is a period of transition of the learning system from teacher-centered to student-centered. It makes students more effective in learning, and the teacher only acts as a facilitator. The also stated in the 2013 curriculum. One of the principles of the 2013 curriculum is that students learn from various learning sources. Learning resources can be in the form of print media or electronic media.

Physics is a part of natural science deals with physical events in the scope of space and time. Learning physics by connecting the material with everyday life as a learning resource will improve the learning process [1]. The can lead to a curious attitude of students to find out more about the material studied [2]. When studying physics, students need to understand the concepts of physics, not just memorize them. Therefore, the teacher's role is to provide several learning resources to help students learn, and teachers can use learning media when the learning process is in progress.

Media is a teaching material made as attractive as possible to make students interested and understand the learning material. Learning media is a tool in learning to facilitate effective and efficient learning [3]. Currently, there are many learning media that teachers can use. The teacher only needs to choose the media suitable for the material to be taught, and the media can achieve the learning objectives. Learning media expect to be able to

improve student learning outcomes. Learning outcomes are competencies that students obtain after the learning activities are completed [4]. Learning outcomes include cognitive, affective, and psychomotor aspects.

The problems students face in learning physics are that students don't like to study physics. It is difficult to understand the material because of the dense material, memorizing and counting, and not contextual learning, and the teacher only uses the lecture method [5]. Teachers don't use learning media and do not connect physics material with everyday life. Therefore, students don't have the motivation and interest in learning, so that the learning outcomes of physics are low. So, teachers need to use ICT-based physics learning media to support student learning outcomes.

ICT-based learning media as a learning resource can make because students more motivated, independent, and more actively participate. Students can find information about the material studies from various available sources. Learning time is also more effective and efficient because students can learn wherever, whenever, and however, not only expecting what is in school. Students can return to studying the material outside of school by using more varied sources than when at school.

Meta-analysis is an analytical study of various analyzes of a large collection of individual research analysis results with the aim of integrating a conclusion [6]. Data analysis is to find the value of effect size. The effect size reflects the magnitude of the relationship between variable in each study and depends on the data used [7]. This meta-analysis used articles published in the last ten years (2011-2021). There are many studies on the impact of ICT-based physics learning media on student learning outcomes. This study has a purpose, namely to see the impact of ICT-based physics learning media on student learning outcomes based on grade level, ICT-based learning media, learning material units, and online/offline ICT media.

II. METHOD

Meta-analysis is the research method used. Meta-analysis is research that examines several journals. Meta-analysis research is an effort to summarize various research results quantitatively, which will later be processed statistically [8]. The meta-analysis research procedures are (1) formulating research questions, research questions regarding variables must be straightforward, (2) literature search, (3) coding procedures, giving each article a code so that the information contained in the article is visible, (4) effect size, grouping the data to calculate the effect size, (5) statistical analysis, calculating the effect size for each article and then calculating the average of each article, (6) Conclusion and interpretation, drawing conclusions after comparing all the research results found [9].

The articles used to consist of 17 national articles and three international articles published in 2011-2021. The criteria for the articles used are (1) with the theme of ICT-based physics learning media on student learning outcomes, (2) the last ten years published in 2011-2021, (3) available pretest and posttest average scores. To calculate the size value of the effect, use the equation:

1. The effect size formula for one sample group, if known pretest-posttest average values and standard deviations pretest-posttest:

$$ES = \frac{\bar{x}_{post} - \bar{x}_{pre}}{SD_{pre}} \qquad (1)$$

Note:
ES = Effect size
X_{POST} = Posttest mean
X_{PRE} = Pretest mean
SD = Standard deviation

2. The effect size formula for differences between two classes that only have posttest data from the mean along with the standard deviation of the two classes:

$$ES = \frac{\bar{x}_E - \bar{x}_C}{SD_C} \qquad (2)$$

Note:
ES = Effect size
X_E = Experimental class mean
X_C = Control class mean
SD = Standard deviation

3. The effect size to test two groups that have a known mean and standard deviation of the pretest and posttest of the two classes:

$$ES = \frac{(\bar{x}_{POST} - \bar{x}_{PRE})_E - (\bar{x}_{POST} - \bar{x}_{PRE})_C}{\frac{SD_{PREC} + SD_{PREE} + SD_{POSTC}}{3}} \quad (3)$$

Note:
ES = Effect size
X_{postE} = The mean of posttest experiment class
X_{preE} = The mean of pretest experiment class
X_{postC} = The mean of posttest control class
X_{preC} = The mean of pretest control class
SD_E = Standard deviation of experiment class
SD_C = Standard deviation of control class

4. To difference test of two related classes if the experiment class and control class have the same t-test value, the number of experimental classes, and the number of control classes:

$$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}} \quad (4)$$

Note:
ES = Effect size
t_h = Test results t
n_E = Number of experiment class students
n_C = Number of control class students [10]

The effect size results are interpreted into the effect size criteria in Table 1.

Table 1. Effect Size (ES) Criteria

ES	Criteria
$0 < ES \leq 0,2$	low
$0,2 < ES \leq 0,8$	medium
$ES > 0,8$	high

(Source: Cohen [11]

III. RESULTS AND DISCUSSION

The first part of the research is about the impact of ICT-based physics learning media on the learning outcomes of senior high school students based on grade level. The result effect size of each article is then averaged. The average value of each article based on grade level used 17 national journals and three international journals can see in Table 2.

Table 1. Effect Size Result Based on Grade Level

Grade Level	Article Code	Effect Size	Average Effect Size	Criteria
X	N1	2,06	1,1	High
	N2	0,92		
	N3	1,09		
	N4	1,28		
	N5	0,42		
	N7	1,10		
	N9	0,63		

Grade Level	Article Code	Effect Size	Average Effect Size	Criteria
XI	N11	2,52	1,38	High
	N12	0,90		
	N14	0,71		
	I3	0,47		
	N6	1,28		
	N15	3,75		
	N16	0,70		
	N17	0,52		
	I2	0,67		
XII	N8	1,16	1,09	High
	N10	1,16		
	N13	1,25		
	I1	0,79		

Based on Table 2, the outcome on grade level for grades X, XI, and XII both have have one criteria of effect size that is high criteria, which mean give a high effect on student learning outcomes. The number of each article based on grade X is eleven article, grade XI is five article and grade XII is four article.

The effect sizes for different grade levels positively affect each grade level, where the effect is higher in grade XI (1,38) compared to grade X (1,1) and grade XII (1,09). This difference in effect size is because each article has data that is able to calculate different effect size, so the calculation results are also different. Although the effect sizes are different, the impact of this ICT-based physics learning media has a high effect at every grade level. There is an impact of ICT-based learning media on the learning outcomes of class X students [12]. ICT-based learning media impact the learning outcomes of class XI students [13]. ICT-based learning media also impact the learning outcomes of class XII students [14]. Therefore, ICT-based physics learning media effective uses for classes X, XI, and XII senior high school. ICT-based learning media is suitable for application at all grade levels on senior high school. ICT-Based learning media can increase the enthusiasm of students and help students who have difficulty in learning to improve learning outcomes. So, ICT-Based physics learning media is effectively used at all grade levels on senior high school.

The second part of the research is about the impact of ICT-based physics learning media on the learning outcomes of senior high school students based on ICT-based learning media. The results effect size of each article is then averaged. The average value of each article based on ICT-based learning media used 17 national journals, and three international journals can see in Table 3.

Table 2. Effect Size Result Based on ICT-Based Learning Media

ICT-Based Learning Media	Article Code	Effect Size	Average Effect Size	Criteria
Presentation based	N1	2,06	1,10	High
	N14	0,71		
	N17	0,52		
Web	N5	0,42	0,60	Medium
	I1	0,79		
Virtual Eksperimen	N3	1,09	1,07	High
	N4	1,28		
	N6	1,28		
	N8	1,16		
	N10	1,16		
	N12	0,90		
	I2	0,67		
Macromedia Flash	N2	0,92	0,77	Medium
	N9	0,63		
Adobe Flash	N7	1,10	1,81	High
	N11	2,52		
Videos	N15	3,75	2,22	High
	N16	0,70		
E-Book	N13	1,25	0,86	High
	I3	0,47		

Based on Table 3, the outcome on ICT-based learning media have two criteria, namely high and medium. High criteria effect have five learning media and a medium effect for two learning media, which mean give effect on student learning outcomes. The number of each article based on ICT-based learning media on presentation based media that is Prezi media and Power Point media is three article, Web media is two article, Virtual Eksperimen media that is PhET media and Virtual Experimental Augmented media is seven article, Macromedia Flash media is two article, Adobe Flash media is two article, Videos media is two article and E-Book media is two article.

High criteria effect on student learning outcomes on Videos media (2,22); Adobe Flash media (1,81); presentation based media that is Prezi media and Power Point media (1,10); Virtual Eksperimen media that is PhET media and Virtual Experimental Augmented media (1,07); and E-Book media (0,86). Meanwhile, Macromedia Flash (0,77) and Web media (0,60) have a medium effect size. This difference in effect size is because each article has data that is able to calculate different effect size, so the calculation results are also different. Although the effect sizes are different, the impact of ICT-based physics learning media based on ICT-based learning media has a high and moderate effect on student learning outcomes.

ICT-based learning media is a learning media that uses computer technology. Utilization of ICT in the field of education is learning material that can be accessed easily in an interactive form through a computer network [15]. Ease of learning outside the classroom and being able to help teachers get information about learning materials is a function of ICT-based learning media [16]. So, using ICT-based learning media provides benefits for teachers and students as learning media with the help of computers. Adobe Flash media is an animation learning media. Creating animations on Adobe Flash media is convenient because the buttons for drawing objects can be moved. Because of the ease of making this animation, the Adobe Flash application can use by everyone. Adobe Flash media influences the learning outcomes of senior high school students [17]. Therefore, using Adobe Flash media with a high category positively affects student learning outcomes. PhET is a site that provides simulations for learning physics, biology, chemistry and mathematics where these simulations are provided free of charge by the University of Colorado [18]. PhET can be accessed by anyone because access PhET is not difficult. PhET media also has attractive features and displays so that it can attract the attention of students. PhET media presents physical phenomena that are more visible than using teaching aids. PhET media can affect student learning outcomes compared to classes that do not use PhET media [19]. Prezi is one of the media for presentations that is equipped with a feature to zoom in and out of presentations so that it can attract the attention of students because it is different from other presentation media. Prezi that the learning outcomes obtained after using Prezi media are in the good criteria so that this Prezi media can be accepted by students [20].

The role of ICT in learning is as a presentation medium in the form of animation or cartoons and as a medium for independent learning by students [21]. The use of ICT-based learning media makes the learning materials taught by the teacher easier for students to understand because of animations or cartoons so that students can see the process of the material being studied. There are many ICT-Based learning media that have a positive effect on student learning outcomes. Then ICT-Based learning media is effectively used and can improve students learning outcomes based on ICT-Based learning media.

The third part of the research is about the impact of ICT-based physics learning media on the learning outcomes of senior high school students based on learning material units. The results effect size of each article is then averaged. The average value of each article based on learning materials used in 13 national journals and three international journals can see in Table 4.

Table 3. Effet Size Result Based on Learning Material Units

Learning material units	Article Code	Effect Size	Average Effect Size	Criteria
Thermodynamics	N1	2,06	1,12	High
	N2	0,92		
	N5	0,42		
	N7	1,10		
Electrical	N3	1,09	0,98	High
	N8	1,16		
	N10	1,16		
	N14	0,71		
Mechanics	I1	0,79	1,73	High
	N6	1,28		
	N9	0,63		
	N11	2,52		
	N15	3,75		

Learning material units	Article Code	Effect Size	Average Effect Size	Criteria
Quantum Physics	I3	0,47	0,96	High
	N13	1,25		
	I2	0,67		

Based on Table 4, the outcome on learning material units have one criteria of effect size that is high criteria which mean give a high effect on student learning outcomes. Physics learning materials are combined in one unit based on branches of physics.The number of each article based on learning material units on Thermodynamics is four article, Electrical is five article, Mechanics is five article, Quantum Physics is two article.

High impact on the material units of Mechanics (1,73); Thermodynamics (1,12); Electrical (0,98) and Quantum Physics (0,96). This difference in effect size is because each article has data that is able to calculate different effect size, so the calculation results are also different. Although the effect sizes are different, the impact of ICT-based physics learning media based on this unit of learning material gives a high effect on student learning outcomes. The unit of electrical learning material often creates misconceptions for some students [22]. Misconceptions can be reduced by using ICT-based physics learning media that can display animations for these problems. By using ICT-based learning media can improve student learning outcomes [23]. When studying electrical material, it is easier to understand the material by doing practicum using ICT-based learning media. Because it will make practicum participants able to use and add to the abstract knowledge learning process to be easier to understand and can do electrical practicum as if it were more real.

In the thermodynamics unit of matter there is material about temperature and heat. The material of temperature and heat contains a lot of material and cases that are difficult to understand if how to convey it only use the lecture method. One of them is the concept of changing the state of matter. The melting point of water is at 0^oC and the boiling point is at a temperature of 100^oC, this material is very easy for students to memorize but very difficult to understand if students don't see it the case directly. Likewise with other materials such as heat transfer and the Black Principle [24].

Many units of physics learning materials do practical work. By using ICT-based learning media as an aid in carrying out practicals, it can make it easier for students to learn do practical directly with their respective groups, the privilege is very useful and very good for student activity, and make power pull to learn, delivery with Ict-based learning media make students more innovative, creative, and effective so that the principle the main thing is to improve efficiency and effectiveness of teaching and learning in school in terms of use time, funds, facilities, and quiet quick and precise. There are many ICT-Based learning media that have a positive effect on student learning outcomes, the ICT-Based learning media is effectively used. As well as can improve student learning outcomes based on the learning material units.

The fourth part of the research is the impact of ICT-based physics learning media on the learning outcomes of senior high school students based on online/offline ICT media. The results effect size of each article is then averaged. The average value of each article based on online/offline ICT media used 17 national journals and three international journals can see in Table 5.

Table 4. Effect Size Result Based on ICT-Based Online/Offline Media

Online/Offline Media	Article Code	Effect Size	Average Effect Size	Criteria
Online media	N1	2,06	1,26	High
	N5	0,42		
	N11	2,52		
	N17	0,52		
	I1	0,79		
Offline media	N2	0,92	1,14	High
	N3	1,09		
	N4	1,28		
	N6	1,28		
	N7	1,10		
	N8	1,16		
	N9	0,63		
	N10	1,16		
	N12	0,90		
	N13	1,25		
	N14	0,71		

Online/Offline Media	Article Code	Effect Size	Average Effect Size	Criteria
	N15	3,75		
	N16	0,70		
	I2	0,67		
	I3	0,47		

Based on Table 5, the outcome on online/offline ICT media have one criteria of effect size that is high criteria which mean give a high effect on student learning outcomes. The number of each article based on online media is five article and offline media is fifteen articles.

High impact on online media (1,26) and offline media (1,14). This difference in effect size is because each article has data that is able to calculate different effect size, so the calculation results are also different. Although the effect sizes are different, the impact of ICT-based physics learning media based on online/offline ICT media has the same high effect on student learning outcomes. ICT-based learning media can be used online or offline, judging from the characteristics and needs of each media. Online learning media can be interpreted as media that have a controller that is operated by the user to control and access user needs, for example downloading material from various sources [25]. Online media is a learning medium that uses media in the form of information technology tools and has telecommunications in the form of the internet [26]. The use of online learning media makes teachers and students able to access various sources of material using the internet network so as to facilitate the learning process. Therefore, using online learning media influences student learning outcomes [27].

Offline learning media is media that does not have a controller or navigation device that can be used by users and this media runs sequentially, for example presentation media that does not have tools to control what the user will do. Offline learning media is a learning media that does not require an internet network to access it. So that students can learn without thinking about whether or not there is an internet network. Offline learning media influences student learning outcomes [28]. Using online media, students can be active in learning, both to ask questions and to access and download materials from various sources via the internet. Student can also work on existing questions as well can see the results of the questions that have been done, and students can work on the questions randomly. Meanwhile, using offline learning media, students get sources only from teachers and materials that already exist in the application program that will be used, students cannot access or download via the internet. Students can work on existing problems and can see the results, but for each student gets the same question, not randomly assigned [29]. When learning to use ICT-based learning media, teachers and students only need to prepare a laptop or cellphone for learning. Next, the teacher and students turn on the application that will be used and then run the application according to the material to be studied. Both of them have a high effect on learning outcomes so that ICT-Based physics learning media is effectively used based on online/offline ICT-Based media. As well as can improve student learning outcomes based on online/offline ICT-Based media.

IV. CONCLUSION

ICT-based physics learning media on student learning outcomes positively influences classes X, XI, and XII, with the highest effect size in class XI. In ICT-based physics, learning media has the highest effect size on Video media. The learning material units has the highest effect size on the Mechanics material units. On online/offline ICT-based media both have a positive impact on high school student learning outcomes, with the highest effect size on online media. It was concluded that ICT-based physics learning media had a good effect on high school student learning outcomes.

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