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The Effect of PhET Virtual Laboratory on Student Physics Learning Outcomes: Meta-analysis

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ABSTRACT

Physics education in schools should be supported by experimental activities. One of the efforts to keep the experiment activities carried out is by utilizing virtual laboratory phet media in learning. This study aims to determine the influence of virtual laboratory phet media on students' physics learning outcomes. The moderator variables are the level of education, learning materials and learning models. This study uses a meta-analysis method that uses articles as a data source. Articles are collected from google scholar and publish or perish that have been accredited by sinta from the 2014-2024 range. From the collection, 41 decent article data were obtained. The article data obtained was analyzed with the help of JASP software and percentage techniques. The results of the analysis show that; 1) the influence of virtual laboratory phet on the overall student physics learning outcomes obtained a summary effect size of 1.122 very high categories, 2). The influence of virtual laboratory phet media on students' physics learning outcomes based on the highest level of education, namely at the high school level, the summary effect size of 1.176 is a very high category, 3). The influence of virtual laboratory phet media on students' physics learning outcomes based on the highest learning material, namely on collision, momentum and implus materials, the summary effect size is 1.572 in the very high category, 4). The influence of virtual laboratory phet media on student physics learning outcomes based on the highest learning model is in the PBL model with a summary effect size of 1.488 very high categories. Based on the results, teachers are advised to apply learning using virtual laboratory phet media at the high school level, especially on collision, momentum and implus materials with a cooperative learning model.

Keywords : Meta Analysis, Virtual Laboratory Phet, Hasil Belajar.

I. INTRODUCTION

Physics as a branch of Natural Sciences is a science that discusses the universe and how it works with the concept of science that is always found in daily life. Physics is a science that studies objects in nature, symptoms, occurrences of natural events and interactions of objects in nature [1]. Physics is not only about mastering knowledge in the form of facts, concepts, or principles, but also experience in the process of discovery using scientific process skills [2]. Therefore, the study of physics in schools should be supported by experimental activities in the laboratory.

Physics learning should be learning based on experimental activities in the laboratory because physics is a collection of knowledge based on facts, which is built on concepts, principles, laws, theories and formulas [3]. The existence of experimental activities in the laboratory in physics learning will strengthen students' physics insights, in the sense that it can improve students' understanding of theory and learning outcomes in physics learning [4]. Therefore, physics learning that involves experimental activities in the laboratory can help improve student physics learning outcomes and can make students more active in ongoing learning and can make it easier for students to understand physics material more easily.

However, in reality not all experiments can be carried out in the laboratory, one of the reasons is because of inadequate laboratory tools and facilities and infrastructure, as well as the characteristics of physical materials and physical concepts themselves which are abstract and cannot be observed with the naked eye [5]. In addition, not all schools have complete laboratory equipment, as well as the cost of materials and safety risks while in the laboratory which are often obstacles that ultimately lead to incompleteness of students' physics learning outcomes [6]. The limited laboratory facilities in schools are a factor that hinders the implementation of experiments in the laboratory in physics learning, causing learning to not take place optimally and ultimately having an impact on the low achievement of student physics learning outcomes.

The second real condition is the low learning outcomes of students and the use of media that has not been maximized to support the physics learning process [7]. In addition, the achievement of student physics learning outcomes in physics subjects is still low, as evidenced by the fact that there are still many student scores that have not reached the Minimum Completeness Criteria (KKM) [8]. The low learning outcomes of student physics are caused by the fact that the physics learning that takes place does not involve experimental activities in the laboratory, and the limited laboratory facilities at school are also the cause of non-implementation of experimental activities in the laboratory and cause incomplete student physics learning results.

One of the solutions to continue to provide learning abilities within these limitations, or as an alternative material in overcoming the problem of implementing experimental activities in schools in order to achieve completeness of student learning outcomes, is by conducting virtual experiment activities using virtual laboratory phet media. Virtual laboratory or commonly referred to as virtual laboratory phet is a series of laboratory tools in the form of computer software based on interactive multimedia [9]. Virtual laboratory phet is operated by a computer and can simulate activities in the laboratory as if the user were in a real laboratory [10].

The use of virtual laboratory phet media makes it easier for students to understand concepts, especially abstract and process-based concepts, can improve student learning outcomes in science-based subjects [11]. Experimental activities using virtual laboratory phet can increase students' learning motivation. Students can be more active in learning and can be an alternative to carrying out real experiments that are difficult to do directly because of the limitations of the tools or materials being experimented with are abstract [12]. In the previous study, it was revealed that students whose learning was assisted by virtual laboratory phet had a high learning outcome, namely 73.55 compared to students who did not get virtual laboratory phet-assisted learning, namely with a learning outcome of 68.29 from the data, it can be seen that learning with the help of virtual laboratory phet media has an effect on student learning outcomes [13].

Research on the use of virtual laboratory phet media has been carried out by many previous researchers and almost all of the research results show that there is a significant influence of the use of virtual laboratory phet media on students' physics learning outcomes. However, there has not been a comprehensive study related to the influence of virtual laboratory phet media on student physics learning outcomes based on the level of investigation, learning materials, and learning models. Therefore, meta-analysis is a very appropriate research method to summarize the results of many virtual laboratory phet studies on students' physics learning outcomes.

Based on the review conducted by the author of 41 articles that meet the criteria for meta-analysis, it produces various values. This identifies significant contradictions for the same variable in various studies. Therefore, the researcher wanted to integrate all information to conclude the effect size value which states the extent of the relationship between the influence of virtual laboratory phet media on the learning outcomes of students in physics in these various studies using the meta-analysis method.

Therefore, meta-analysis is a very appropriate research method to conclude various research results in a wide scope. Based on the background that has been explained previously, the researcher wants to raise a research topic entitled The Influence of Virtual Laboratory Phet Media on Student Physics Learning Outcomes: Meta-Analysis Using the JASP Application (Jeffreys's Amazing Satistics Program).

II. METHOD

The type of research used is meta-analysis research that summarizes various studies using a quantitative approach. Meta-analysis is a technique used to summarize various research results by looking for effect size values [14]. This research focuses on an article with the title The influence of virtual laboratory phet media on students' physics learning outcomes. The research uses articles as the source of data. Where the research stage is carried out by collecting articles, grouping articles and calculating effect size [15]. The collection of articles was carried out using google scholar and publish or perish by using search keywords, namely virtual laboratory media phet, learning outcomes, which were combined with learning models.

For all search results of the articles obtained must be reviewed first before being used in meta-analysis, where the criteria for articles that are considered worthy must be in accordance with the following criteria: 1) The selected article is the latest published in the last 10 years, starting from 2014-2024, 2) The selected article examines the influence of virtual laboratory phet media on students' physics learning outcomes conducted at the junior high and high school levels, 3) The selected article has been published in journals that have been indexed nationally and internationally, 4) The selected article is a publication that already has an International Standard Serial Number (ISSN) as the identity of the publication in print or electronically, 5) The selected article uses an experimental research method, 6) The selected article has statistical data to obtain the effect size value. The steps for selecting articles are guided by PRISMA (Preferred Reporting Items for Systematic review and Meta - Analysis), namely: (1) identification, screening, (3) eligibility, and (4) included. Thus this meta-analysis uses these stages in selecting studies [16]. And it is obtained in the following figure 1.

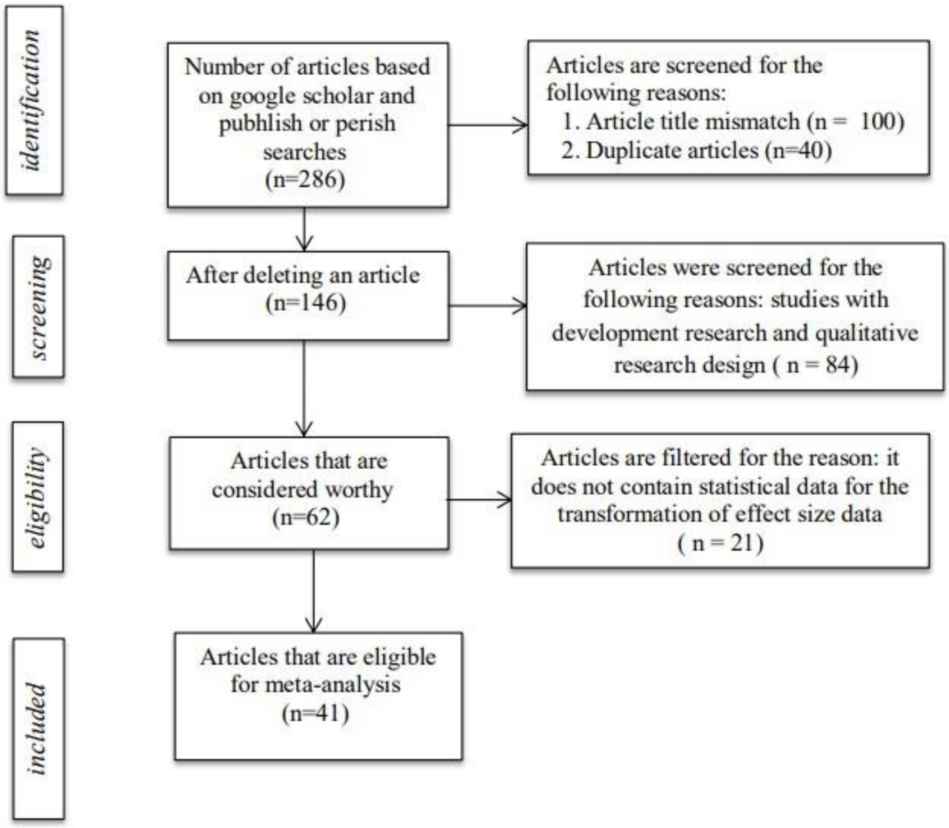

Fig 1. PRISMA Flow Diagram

After going through the screening process, the verified journals are further analyzed and used as research report data. The journals are then recorded to get more detailed information from each journal. The effect size value is also calculated to determine the magnitude of the influence or effectiveness of the implementation of virtual laboratory phet media for each journal. The Ecxel and JASP applications were used to analyze the effect size of each article. The Excel application is used to process the quantitative data obtained to obtain the effect size value of each article. Meanwhile, the application of JASP in meta-analysis is used to analyze heterogeneity, forest plot, funnel plot and publication bias.

To process the data and find the effect size value of each article, it uses the contrass group equation seen in equations 1 and 2.

$$ES = \frac{X_E - X_C}{SD_C} \quad (1)$$

$$ES = \frac{(X_{post} - X_{pre})_E - (X_{post} - X_{pre})_C}{\frac{SD_{preC}+SD_{preE}+SD_{postC}}{3}} \quad (2)$$

Data that are not explicitly reported for the calculation of effect size (missing data), can take advantage of the available statistical information. If there are t-count and F-count values, and the effect size (Vd) variant can use the equation 3, 4, and 5.

$$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_c}} \tag{3}$$

$$ES = \sqrt{\frac{F(n_E + n_C)}{n_E n_C}} \tag{4}$$

$$Vd = \frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)} \tag{5}$$

To minimize data bias, you can use the Hedges correction factor (J). After that, the actual effect size (g) and the error standard (SEg) are obtained. Can use equations 6 and 7.

$$J = 1 - \frac{3}{4df - 1} \tag{6}$$

$$df = n - 2 \tag{7}$$

$$\mathrm{g} = J \times d \tag{8}$$

$$V\mathrm{g} = J \times Vd \tag{9}$$

$$SE\mathrm{g} = \sqrt{V\mathrm{g}} \tag{10}$$

Interpretation of the value of the effect size result criterion.

Table 1. Interpretation of the Effect Size value.

No	*ES*	Kategori
1	ES ≤ 0.15	Negligible
2	0,15 < ES ≤ 0.40	Low
3	0,40 < ES ≤ 0.75	Medium
4	0,75 <ES ≤ 1.10	High
5	ES > 1.10	Very High

(Source: Ref [17])

III. RESULTS AND DISCUSSION

After filtering articles on the influence of virtual laboratory media phet on students' physics learning outcomes, 41 articles were obtained that were worthy of meta-analysis. All the articles taken have met the set criteria, namely the 2014-2024 range, and focus on the level of education, learning materials and learning models. The quantitative data obtained from the article was used to calculate the effect size. Table 2 shows the characteristics and effect sizes of each study.

Table 2. Charactheristics of meta-analysis studies

Author	Years	Level Education	Material	*Model	Number of Sample (n)	Effect Size (g)
Anggraeni et al [18]	2020	JHS	Waves & Optic	-	53	1.166
Alridha et al [19]	2021	SHS	Collision, Momentum & Impluse	PBL	28	0.931
Dachi et al [20]	2023	SHS	Mechanics	PBL	60	0.900
Jauhari et al [21]	2016	SHS	Thermodynamics	PBL	69	2.060
Jamila et al [22]	2023	SHS	Waves & Optic	PBL	55	1.667
Doana et al [23]	2016	SHS	Fluid	Inquiry	64	0.467
Lidiana et al [24]	2018	SHS	Elasticity & Hooke's Law	Discovery	40	0.691
Firmasari et al [25]	2024	SHS	Waves & Optic	PBL	61	0.883
Subiki et al [26]	2022	SHS	Waves & Optic	-	60	0.892
Zainal Arifin et al [27]	2016	SHS	Collision, Momentum & Impluse	Quantum	73	2.337
Rasyidah et al [28]	2018	SHS	Work & Energy	Inquiry	72	0.192
Puspitasari et al [29]	2022	SHS	Electricity & Magnet	-	70	0.808
Syaripudin et al [30]	2023	SHS	Collision, Momentum & Impluse	Learning Cycle	42	1.896
Muthmainnah et al [31]	2017	SHS	Electricity & Magnet	-	64	1.031
Novita et al [32]	2023	SHS	Thermodynamics	PBL	56	1.525
Faradila et al [33]	2022	SHS	Waves & Optic	PBL	60	3.389
Abjul et al [34]	2022	SHS	Waves & Optic	PBL	50	1.762
Tatal et al [35]	2023	SHS	Waves & Optic	Kooperatif	40	1.027
Saputra et al [36]	2020	SHS	Elasticity & Hooke's Law	-	41	1.262
Simbolon et al [37]	2022	SHS	Waves & Optic	Inquiry	40	0.270
Chotimah & Hendri [38]	2018	JHS	Electricity & Magnet	Inquiry	64	0.423
Ririn et al [39]	2020	SHS	Fluid	Discovery	68	1.258
Nailufar & Arjo [7]	2022	SHS	Elasticity & Hooke's Law	Inquiry	56	0.366
Ghiffary [40]	2022	SHS	Mechanics	Kooperatif	70	2.454
Bimo et al [41]	2018	SHS	Fluid	Inquiry	64	0.976
Muzana & Hasanah [42]	2018	SHS	Electricity & Magnet	-	53	1.165
Sunni & Nurlaeli [43]	2022	JHS	Electricity & Magnet	Discovery	49	0.568
Nurhayati et al [44]	2014	SHS	Electricity & Magnet	Kooperatif	72	1.004
Qamaria [45]	2019	SHS	Fluid	Inquiry	76	3.033
Hayati et al [46]	2017	SHS	Mechanics	Inquiry	49	0.838
Prastika et al [47]	2020	SHS	Mechanics	-	47	0.602
Hermansyah et al [48]	2022	SHS	Mechanics	Belnded	45	0.404
Rijal et al [49]	2015	SHS	Fluid	PBL	45	0.399
Putri et al [50]	2016	SHS	Thermodynamics	-	68	0.619
Farid et al [51]	2018	SHS	Waves & Optic	Discovery	50	0.410
Rahma [52]	2021	JHS	Work & Energy	Blended	34	0.858
Siboro & Mujasam [53]	2024	SHS	Fluid	Blended	70	0.847
Febniani et al [54]	2022	SHS	Collision, Momentum & Impluse	Inquiry	40	1.364
Artawan & Syamsu [55]	2022	SHS	Electricity & Magnet	Blended	64	1.566
Jhoni et al [56]	2022	SHS	Elasticity & Hooke's Law	PBL	78	0.848
Tolas et al [57]	2024	JHS	Work & Energy	Discovery	60	1.911
			Average			1.122

In table 2, it can be seen that the articles used are replicated from the range of 2014 to 2024 which have been accredited by sinta. The influence of virtual laboratory phet media on students' physics learning outcomes based on education level is grouped into high school level and junior high school level, where at the high school level there are 36 articles and at the junior high school level there are 5 articles. Meanwhile, the influence of virtual laboratory media on students' physics learning outcomes based on learning materials is grouped into 8 materials, namely elasticity and hooke's law 5 articles, momentum collision and implus 3 articles, thermodynamics 3 articles, waves and optics 9 articles, fluids 6 articles, electricity and magnetism 7 articles effort and energy 3 articles, and mechanics 5 articles. The influence of virtual laboratory phet media on students' physics learning outcomes based on learning models is grouped into 5, namely the inquiry model of 8 articles, the PBL model of 9 articles, the discovery model of 5 articles, the blended model of 3 articles, and the cooperative model of 3 articles.

The effect size value obtained after data analysis was the lowest effect size of 0.192 included in the low category, while the highest effect size obtained was 3.389 included in the very high category. The summary effect obtained from the study was 1.122 which was included in the very high category. The results of the research obtained are in accordance with previous research that also researched the influence of virtual laboratory media phet. The effect of virtual laboratory on student ability with an effect size value of 0.804 which is in the high category [58]. Using virtual media of the phet laboratory, learning is more interactive and able to improve students' physics learning outcomes [59]. Virtual labs help students improve a more effective learning experience [60]

The Effect of Virtual Laboratory Phet on Student Physics Learning Outcome

The results of the effect size of the study were used to see how much the virtual laboratory media phet had on students' physics learning outcomes. From the results of the effect size test, the data obtained in the heterogeneity test are the values of Q, p-value and I. The Q and I values obtained are the heterogeneity values of the study, but the I value shows the actual heterogeneity of the distribution of the data obtained. There is an influence of virtual laboratory media phet on students' physics learning outcomes if the p-value obtained is p<0.05. In the research, the analysis was carried out using JASP software. The data from the calculation of the heterogeneity test are shown in table 3.

Table 3. Heterogenity Test Learning Outcome

Variabel	Overall	95% Confidence	
		Lower	Upper
Number of Sample (K)	41		
Heterogenity test (Q)	222.976		
Probability value (p)	<0.001	0.900	1.344
Standar score (z)	9.911		
Estimate (r)	1.122		
Heterogeneity test (τ^2)	0.437	0.272	0.812
Heterogeneity test (τ)	0.661	0.522	0.901
Heterogeneity test (I^2)	83.945	76.509	90.663
Heterogenity test (H^2)	6.229	4.257	10.710

In table 3, it can be seen that the effect size of the 41 analyzed articles is heterogeneous with a Q value obtained of Q = 222.976 p < 0.001 using a significance level of 95% with a confidence level (α = 0.05). Thus, the random effect model is more suitable to be used to estimate the average effect size of the 41 articles analyzed. A high heterogeneity value can be assumed that the data used is good. The results of the analysis using a random effect model showed that there was a positive correlation between the influence of virtual laboratory phet media on the physics learning outcomes of students with a score of 1.122, which was in the very high category [17]. The z-score value of 9.911 shows that there is a significant increase in the influence of virtual laboratory phet media on students' physics learning outcomes. This result is in line with previous research on the application of virtual laboratory media PHET on student learning outcomes [61]. In line with by [63]. The use of virtul laboratory phet media in learning makes it easier for students to improve learning outcomes [62]. In table 3, using the significance level of 95%, the lower limit of the effect size is 0.900 and the upper limit is 1.344. The average value of the effect obtained was 1.122 in a very high category.

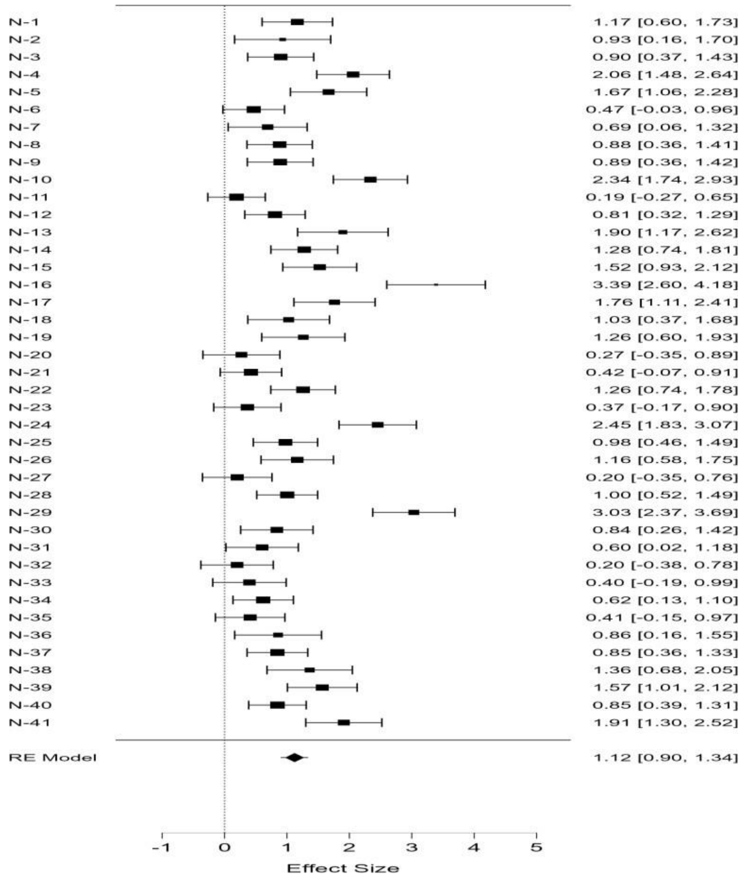

Fig 2. *Forest Plot*

From the forest plot, it can be observed that the effect size of the 41 analyzed articles varies, which ranges from 0.12 to 1.34. With an average effect size of 1.122.

The Effect of Virtual Laboratory Phet Based on Education Level

The result of this study is the effect size of the influence of virtual laboratory phet media on physics learning outcomes based on education levels. The level of education taken in this study is junior high school and high school level. Calculations were carried out on combined heterogeneity (Qw) and intermediate heterogeneity (Qb) to see the influence of virtual laboratory phet media on students' physics learning outcomes based on education level. Table 4 shows the value of the moderator variable that measures the influence of virtual laboratory phet media based on education level.

Table 4. Level Education

Moderator	Junior High School (JHS)	Senior High School (SHS)
K	5	36
Q	21.092	192.360
z	2.406	9.746
r	0.739	1.176
τ^2	0.384	0.435
τ	0.620	0.659
I^2	81.940	83.833
H^2	5.537	6.186
95% Lower	0.137	0.939
95% Upper	1.341	1.412
Qw	213.452	
Q_B	9.524	
p-value	0.002	

Based on table 4, the influence of virtual laboratory phet media is found at the high school and junior high school levels. The number of articles obtained at the high school level was 36 articles, while at the junior high school level there were 5 articles. The total effect size value obtained at the high school level is 1,176 in a very high category. Meanwhile, at the junior high school level, a summary effect size value of 0.739 was obtained in the medium category.

The p-value obtained is 0.002, meaning it is greater than 0.05. These results show that there is a significant influence of the influence of virtual laboratory phet media on students' physics learning outcomes if applied at the junior high and high school levels. Where virtual laboratory phet media is more effective at the high school level than at the junior high school level. High school students generally have more mature cognitive abilities, so the complex and in-depth learning approach with virtual laboratory phet media becomes interesting. And high school students are already able to analyze a phenomenon from many points of view [63]. The development of organs that support cognitive function, such as the brain, as we age, allows individuals to have more complex cognitive abilities [64] The level of thinking of students at the high school level is higher than that of students at the junior high school level [8].

The Effect of Virtual Laboratory Phet Based on Material Learning

The result of this study is the effect size of the influence of virtual laboratory phet media on physics learning outcomes based on learning materials. Calculations were carried out on combined heterogeneity (Qw) and intermediate heterogeneity (Qb) to see the influence of virtual laboratory phet media on students' physics learning outcomes based on education level. Table 5 shows the value of the moderator variable that measures the influence of virtual media laboratory information on learning materials.

Table 5. Materials

Moderator	Elastisitas & Hukum Hooke	Momentum & Implus	Termodinamika	Gelombang dan Optic	Fluida	Listrik & Magnet	Usaha & Energy	Mekanika
K	6	3	3	8	6	7	3	5
Q	13.417	9.150	14.705	53.859	46.261	18.117	19.458	30.610
z	4.720	3.730	3.255	3.802	2.987	5.136	1.914	2.622
r	0.999	1.572	1.388	1.274	1.150	0.915	0.974	0.994
τ^2	0.172	0.411	0.466	0.801	0.812	0.150	0.685	0.631
τ	0.415	0.641	0.682	0.895	0.901	0.387	0.828	0.794
I^2	64.930	77.403	85.493	89.725	91.560	67.610	88.602	87.947
H^2	5.240	4.425	6.893	9.732	11.849	3.087	8.774	8.297
95% Lower	0.584	0.746	0.552	0.617	0.396	0.566	-0.023	0.251
95% Upper	1.414	2.397	2.223	1.930	1.905	1.264	1.971	1.736
Qw				205.577				
Q_B				17.399				
p-value				0.015				

Based on table 5, the influence of virtual laboratory media phet is found in elasticity and hooke's law material 6 articles, momentum and impuls 3 articles, thermodynamics 3 articles, waves and optics 8 articles, fluids 6 articles, electricity and magnetism 7 articles, effort and energy 3 articles and mechanics material 5 articles. The total effect size value obtained on the elasticity material and the Hooke's law was 0.999 in the high category. Meanwhile, momentum and impuls materials of 1.527 categories are very high. In thermodynamic materials of 1.388 categories are very high. Wave and optic matter of 1.274 categories is very high. Meanwhile, fluid material 1.150 is very high. Electrical and magnetic materials were obtained 0.915 in the high category. Business materials and energy obtained a total effect size of 0.974 in the high category. Meanwhile, in the mechanics material, a summary effect size of 0.994 was obtained in the high category.

The p-value obtained is 0.015 which means it is less than 0.05. These results show that there is a significant difference in the influence of virtual laboratory media based on learning materials. In this study, the highest value of summary effect size in impact, momentum and implus material was obtained with a summary effect size of 1.527 with a very high category. Meanwhile, electrical and magnetic materials are at the lowest level with a summary effect size of 0.915 in the high category. Thus, it was concluded that the virtual laboratory phet media was most effectively applied to the learning materials of collision, momentum and implus. Previous research showed that the learning outcomes of students on impact, momentum and implus materials increased when using virtual laboratory phet media [27]. Collision, momentum and implosion materials are related to nature and phenomena that often occur in daily life so that with the virtual media of the phet laboratory, students can observe visualizations in real life and find concepts through investigative activities [54].

However, it is also effective on electrical and magnetic materials even though it has the lowest effect size value compared to other learning materials, but the effect size value on electrical and magnetic materials is also in a high category, which means that the virtual laboratory media also has a significant influence on electrical and magnetic materials. Virtual laboratory phet media has an influence on students' physics learning outcomes [29]. Learning with virtual laboratory phet experiments is able to increase student motivation and learning outcomes [31].

The Effect of Virtual Laboratory Phet Based on Model Learning

The result of this study is the effect size of the influence of virtual laboratory phet media on physics learning outcomes based on the defense model. Calculations were carried out on combined heterogeneity (Qw) and intermediate heterogeneity (Qb) to see the influence of virtual laboratory phet media on students' physics learning outcomes based on education level. Table 6 shows the value of the moderator variable that measures the influence of virtual media laboratory phet learning model.

Table 6. Model

Moderator	Inquiry	PBL	Discovery	Blended	Kooperatif
K	9	10	5	4	3
Q	62.230	55.528	21.804	11.077	14.882
z	3.353	5.440	2.894	3.092	3.122
r	0.954	1.414	0.892	0.871	1.488
τ^2	0.645	0.578	0.388	0.230	0.591
τ	0.803	0.760	0.623	0.480	0.769
I^2	89.085	86.419	82.034	72.995	86.960
H^2	9.162	7.363	5.566	3.703	7.669
95% Lower	0.396	0.905	0.288	0.319	0.554
95% Upper	1.511	1.924	1.495	1.424	2.423
Qw			165.521		
Q_B			20.134		
p-value			0.0005		

Based on table 6, it is known that the summary effect size obtained in the inquiry model is 0.954 in the high category. Meanwhile, in the PBL model, a total effect size value of 1.414 was obtained in the very high category. In the discovery model, a summary effect size of 0.892 was obtained in the high category. The blended model has a total effect size of 0.871 in the high category. And in the cooperative model, a total effect size of 1.488 was obtained in a very high category.

The p-value obtained is 0.0005 which means it is smaller than 0.05 so that from these results there is a difference in the influence of virtual laboratory media based on the learning model used. When compared to the cooperative model, the summary effect size value is high and the blended learning model gets the lowest value. The cooperative model assisted by phet media can attract students' attention because abstract physics materials and concepts can be observed by students directly [44]. Learning with a cooperative learning model with the help of phet simulation media makes the material learned easier for students to understand [40].

Publication Bias

A common concern in meta-analysis is the presence of publication bias in studies. The methods used to detect this and overcome bias are funnel plot, Egger's test (regression method), Funnel Plot Asymetry (rank correlation) and file-safe N. Funnel plot will determine whether the research conducted is symmetrically distributed (no publication bias) or asymmetrical (there is publication bias) [17]. Figure 3 can be seen that there are no colorless dots or open dots in the plot funnel image above. This proves that there are no articles with publication bias. However, because the results of the funnel plot are difficult to conclude whether the funnel plot is symmetrical or asymmetrical, a rank correlation test was carried out using Kendall's τ, a regression coefficient using Egger's Test, and using a drawer analysis. The following results of the bias publication test are presented in table 7.

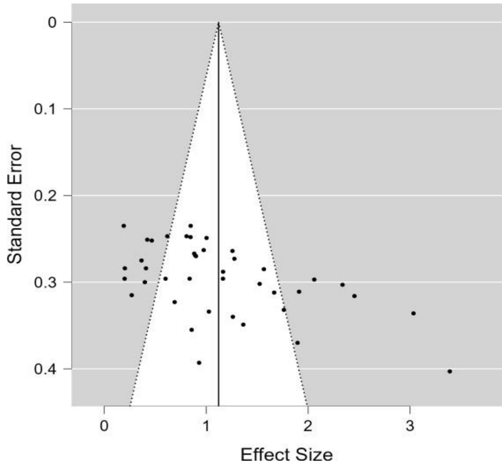

Fig 3. *Funnel Plot*

Figure 3 can be seen that there are no colorless dots or open dots in the plot funnel image above. This proves that there are no articles with publication bias. However, because the results of the funnel plot are difficult to conclude whether the funnel plot is symmetrical or asymmetrical, a rank correlation test was carried out using Kendall's τ, a regression coefficient using Egger's Test, and using a drawer analysis. The following results of the bias publication test are presented in table 7.

Table 7. Publish Bias Test

Variabel	Egger's Test	File drawer Analysis	Funnel Plot Asymetry
Fail-Safe N		8661.000	
Kendall's τ			0.379
p-value	0.001		0.001
z	3.910		

Funnel plots display research samples in the form of points that are difficult to justify whether the plot is symmetrical or not, so another approach is needed. The rank correlation and regression methods with a p-value of 0.001 showed that the p-value was less than the α value (0.05). This can be interpreted that the funnel plot formed is symmetrical or in other words, there is no occurrence or no evidence of publication bias is found [17]. While with fail-safe N obtained a value (8661) tested with the Rosenthal equation obtained 5K + 10 (215), the value shows 215 < 8661.000. With a significance target of 0.05 and p < 0.001, it can be concluded that there is no publication bias in the results of the meta-analysis. With some of these approaches, it can be seen that there is no publication of data bias, so it can be concluded that there is an influence of virtual laboratory phet media on students' physics learning outcomes.

IV. CONCLUSION

Based on the meta-analysis conducted on 41 research articles, the results were obtained that there was an influence of virtual laboratory phet media on the learning outcomes of physics students by 1.122 with a very high influence. The influence of virtual laboratory phet media based on the level of education where with p<0.05 there is a significant influence of the influence of virtual laboratory phet media on student physics learning outcomes if applied at the junior high and high school levels. Where the virtual laboratory phet media is more effectively applied at the high school level with a summary effect size of 1,176. The influence of virtual laboratory media on physics learning outcomes based on learning materials was highest on collision, momentum and implosion materials with a summary effect size of 1.572. Meanwhile, the influence of virtual laboratory phet media on students' physics learning outcomes based on the highest learning model was obtained in the cooperative model with a summary effect size value of 1.488. The results of the publication bias test through the egger's test, funnel plot asymmetry and file drawer analysis obtained a value of p<0.05 which means that there is no publication bias from the distribution of the data studied in the meta-analysis.

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