

META-ANALYSIS OF THE EFFECT OF THE DISCOVERY LEARNING MODEL ON STUDENT LEARNING OUTCOMES IN PHYSICS LEARNING

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ABSTRACT

The 21st century is characterized by rapid advances in science and technology. These advances have an impact on education. In education, there is a curriculum that requires students to have good learning skills and results. The real conditions found in the field are low student' learning results, the learning model is only used at one grade level and one unit of material. One model that can use to solve this problem is the discovery learning model. Research with the discovery learning model has been widely done and has not been summarized as a whole. Therefore, this research aims to determine the effect size of the discovery learning models through meta-analysis research reviewed based on aspects of knowledge, grade level, and subject matter. Meta-analysis research is conducted by summarizing, reviewing, and analyzing research data from the results of previous research. The articles reviewed in this research totaled 22 articles. The results of this research obtained, that the discovery learning model is effectively used in physics learning against student learning outcomes in the aspect of learning within an effect size of 0.196. At the class level, the model of discovery learning is more effective in class XI than class X with an effect size of 0.949. While viewed from the learning material unit, the model of discovery learning is more effectively applied to fluid mechanics material with an effect size of 1,196. So can be concluded the discovery learning model is very supportive of students' learning outcomes in high school physics learning.

Keywords: Discovery Learning; Effect Size; Learning Outcomes; Meta-Analysis.



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I. INTRODUCTION

The 21st century is marked by rapid advances in science and technology. These advances have an impact on various aspects of life, including the field of education. Curriculum development is one of the efforts made by the government to improve the quality of education[1]. The learning curriculum applied by the education system often changes, until now the 2013 revised 2017 curriculum is used. This curriculum demands that students have various skills and have success in learning. To meet these demands can be used models in learning.

Implementations the right model of learning will greatly support student learning success. The learning model is a plan that can be used to design learning materials and guide teacher activities[2]. Models that can be used in learning such as discovery learning models. Discovery learning is a model to encourage student to learn actively by getting and analyzing by themselves, then the result obtained will be loyal and can be remembered for a long time[3]. Learning outcomes obtained by students in learning can be viewed from the acquisition of student learning outcomes. Learning outcomes are an assessment to measure the level of students' understanding of learning[4]. Learning outcomes cover three domains, namely the realm of knowledge, attitudes, and skills. The learning outcomes will show how students' ability to master learning.

Based on a review conducted on 22 articles related to current learning, there are differences between conditions in the field with ideal conditions. The reviews have been carried out in this study are to determine student learning outcomes, namely by reading from several articles regarding to use of discovery learning models on student learning outcomes. The real conditions in the field are first, in the learning process at school, teachers often use only one model[5,6]. Teachers only use conventional learning models in delivering learning to students[7]. The learning carried out is still verbal[8] students tend to be passive [9] and receive knowledge according to what is given by the teacher with teacher-centered learning, namely one-way learning (teacher-oriented) [10] The method used by the teacher can be in the form of question and answer activities, take notes, come forward working on questions [11] and do homework at home and do not use models that support practicum[12,13]. Related to the use of the model that does not vary, learning activities in the classroom tend to be rigid, the class is less dynamic, and students are more listeners in learning[14]. Students only often memorize formulas and do not understand the concept of physics so that student scores are low[15] and students are less active in learning [16].

Second, student learning outcomes at school still have not reached the KKM[17]and belong to the low category[18]. The low student learning outcomes are the result of the lack of student learning and the lack of active students in the learning process[19]. Teachers rarely involve students in learning[20]. Students are not allowed to rediscover and construct their ideas, which causes students to often forget and cannot apply the learning they have learned. [21]. In addition, the low understanding and interest in student learning also affect student learning outcomes[22] In learning activities, many students prefer to play and tell stories to their friends when the teacher explains learning [23]. Meanwhile, when the teacher tests the students by asking questions, the students just stay silent[24]. So that the learning carried out is not optimal and the results obtained by students are not optimal.

On the real conditions that have been described, the model of discovery learning can be used as a solution. Related research related to learning the discovery learning model has been done by many previous researchers. These studies have had mixed results, and there is no overall summary of the research. Therefore, there is a need for further meta-analysis related to this research. Meta-analysis is research that uses existing and previously used studies that are carried out systematically and quantitatively to obtain accurate conclusions[25]. This meta-analysis research was conducted to determine the effectiveness and calculate the effect size of the discovery learning model for use in physics learning. The reasons for choosing meta-analysis as the research method are: First, previous studies used only one discovery, learning model. Second, previous research covers only one level of education. Third, previous research only determines the effect on student learning outcomes. Therefore, this research is entitled "meta-analysis the effect of use discovery learning models in physics learning senior high school on student learning outcomes".

II. METHOD

This reseach used meta-analysis as the type of reseach. Meta-analysis is the newest development technique to aid the researchers to find consistent or inconsistent in the cross-examination of research results[26]. The variables of this study consist of the independent variable are the discovery learning model, the dependent variable is the learning outcome and the moderator variable is the realm of competence, grade level, and learning materials. The sample in this research amounted to 22. The procedure used consists of determine the topic, determine the period of research results for data sources, looking for related articles with the problem or topic to be researched, Read article titles and abstracts, focusing on research, categorizing articles, analyze and compare research results according to their categories and draw conclusions.

The analysis technique used a quantitative approach through the calculation and analysis of the data already in the article. There are three steps used in the data analysis technique. First, descriptive statistics. Namely identifying variables found and identifying article statistical data (mean and standard deviation and t-value). Second, effect Size. Effect size is a measure of the magnitude of the effect of a variable with other variables. To calculate the effect size using the equation Glass, Mr. Gaw & Smith [27], calculating effect size using Cohen's d equation:

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

- Note:
- ES(d) = Cohen's effect size
 - X_{post} = The average of posttest value
 - X_{pre} = The average of pretest value
 - SD_{within} = Standard deviation

To test the comparison of two independent samples are:

$$ES(d) = \frac{\bar{x}_E - \bar{x}_C}{SD_{within}} \dots\dots\dots(2)$$

Note:
 ES (d) = Cohen’s effect Size
 \bar{x}_E = The average experimental
 \bar{x}_C = The average control
 SD_{within} = Standard Deviation

The formula for the effect size of the comparison test of two independent samples for the mean value of the pretest and the average value of the posttest is known and the standard deviation of the two experimental groups is known.

$$ES(d) = \frac{(\bar{x}_{post} - \bar{x}_{pre})_E - (\bar{x}_{post} - \bar{x}_{pre})_C}{SD_{within}} \dots\dots\dots(3)$$

Note:
 ES (d) = Cohen’s effect Size
 \bar{x}_{post} = The average posttest experimental
 \bar{x}_{pre} = The average pretest experimental
 \bar{x}_{post} = The average posttest control
 \bar{x}_{pre} = The average pretest control
 SD_{within} = Standard Deviation

The formula for the effect size of the comparison test of two independent samples if the t-value is known.

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

Note:
 ES (d) = Cohen’s effect Size
 t = t-test
 n_E = Number sample of experimental
 n_C = Number sample of control

After obtaining the effect size data using the Cohen's d equation from the article, the calculation of variance d is then carried out using the formula:

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

$$SE_d = \sqrt{Vd} \dots\dots\dots(6)$$

Note:
 V_D = Variance effect
 SE_d = Standard error effect (SE_M)

In the processing of effect size data, there is a bias in d this is because the processing is carried out on the sample, not in the population. This data bias can be reduced by using the Hedges g equation. To convert the value of d into Hedges g, equation j is used, namely:

$$J = 1 - \frac{3}{4df - 1} \dots\dots\dots(7)$$

Where df is a degree of freedom obtained by the formula:

$$df = n_E + n_C - 2 \dots\dots\dots(8)$$

So that the value of the effect size can be determined by a formula, namely:

$$g = J \times d \dots\dots\dots(9)$$

$$Vg = J^2 \times Vd \dots\dots\dots(10)$$

$$SE_g = \sqrt{Vg} \dots\dots\dots(11)$$

Note:

- J = Hedges factor corection
- g = Actual effect size
- V_g = Variance effect
- SE_g = Standard error effect varians

After calculate the effect size, then calculate the summary effect size with formula fixed effect model or using formula random effect model using the formula:

$$M^* = \frac{\sum_{i=1}^k Wi Yi}{\sum_{i=1}^k Wi} \dots\dots\dots(12)$$

$$V_M = \frac{1}{\sum_{i=1}^k Wi} \dots\dots\dots(13)$$

$$SE_M = \sqrt{V_M} \dots\dots\dots(14)$$

Note:

- Wi* = Effect size of the study to-i, and
- Yi * = Variance Effect size study to-i
- V_M = Variance effect
- SE_M = Standard error effect (SE_M)

Then calculate the Lower limit (LL_M) and the Upper limit (UL_M) by using the following formula:

$$LL_M = M - 1.96 \times SE_M \dots\dots\dots(15)$$

$$UL_M = M + 1.96 \times SE_M \dots\dots\dots(16)$$

Perform hypothesis tests by calculating the value of Z, and p-value. Calculates the value Z to test the null hypothesis (H₀: true effect θ=0). The formula used to calculate the value Z is as follows

$$Z = \frac{M}{SE_M} \dots\dots\dots(17)$$

$$\text{p-value one-tailed test: } p=1-\Phi(\pm |Z|) \dots\dots\dots(18)$$

$$\text{p-value two-tailed test: } p=1-\Phi(\pm |Z|) \dots\dots\dots(19)$$

The third is result Interpretation. after the effect size is calculated, the effect size value that has been obtained is then interpreted according to the predetermined category at the following levels Table 1.

Table 1. Effect Size Criteria (ES)

| NO | ES | Category |
|----|------------------|----------------|
| 1 | ES ≤ 0.15 | Can be ignored |
| 2 | 0.15 < ES ≤ 0.40 | Low |
| 3 | 0.4 < ES ≤ 0.75 | Currently |
| 4 | 0.75 < ES ≤ 1.10 | High |

| | | |
|---|-----------|-----------|
| 5 | ES > 1.10 | Very High |
|---|-----------|-----------|

III. RESULTS AND DISCUSSION

The results of all article are then analyzed according to the research objectives. The results are then grouped based on the moderator variables of the study. The first results of the research are related to student learning outcomes. The learning outcomes reviewed in this study are aspects of knowledge. The mean value of effect size on learning outcomes is sought using a random-effects model. The overall results of the average summary effect size of the influence of the model of discovery learning on students' learning results are in the following Table 2.

Table 2. The data on the average summary effect size on student learning outcomes

| N | M | SEM | Category | P | =0.05 | |
|----|-------|-------|----------|-------|-------|-------|
| | | | | | Lower | upper |
| 20 | 0.916 | 0.120 | High | 0.000 | 0.680 | 1.151 |

Based on the results of data processing contained in the table, the effect of the discovery learning model on student learning outcomes has an effect size of 0.916 at a 95% confidence interval from 0.680 to 1.151. The effect size shows that the model of discovery learning is in the high category. The confidence interval used is 95% ($\alpha=0.05$) and the p-value test obtained is 0.000, where the p-value < then h_0 is rejected so that the model of discovery learning influences student learning outcomes in the knowledge aspect.

The results of the second research are related to student learning outcomes at grade level. The grade levels reviewed in this study are class X and class XI. Average value summary effect size at the X class level is obtained by using the fixed-effect model while for the XI class level using the random-effects model. The results of processing the average summary effect size of the influence the model of discovery learning on student learning outcomes at each grade level are in the following Table 3.

Table 3. The data of the average summary effect size at the grade level

| Class Level | N | M | SEM | Category | p | =0.05 | |
|-------------|----|-------|-------|----------|-------|-------|-------|
| | | | | | | lower | upper |
| Class X | 13 | 0.811 | 0.071 | High | 0.000 | 0.672 | 0.950 |
| Class XI | 9 | 0.949 | 0.126 | High | 0.000 | 0.703 | 1.196 |

Based on the number of articles, namely 22 articles, for articles at level X, there are 13 articles and for class XI there are 9 articles. The effect size value of learning outcomes in class X is 0.811 with a 95% confidence interval from 0.672 to 0.950 in the high category. The class XI effect size value of 0.949 with a 95% confidence interval from 0.703 to 1.196 is also in the high category. After testing the p-value at the level of class X and class XI obtained the same p-value, namely $p < h_0$ is rejected. So it can be concluded that the model of discovery learning affects each grade level with the use of the discovery learning model being more effective in class XI because the effect size value is larger.

The results of the third research are related to student learning outcomes against learning material units. The units of learning material reviewed in this research are thermodynamics, classical mechanics, electronics, and fluid mechanics. The data processing of the average effect size value in the learning material unit uses the fixed effect model in the thermodynamics learning material unit and uses the random effects model in the classical mechanics, electronics, and fluid mechanics units. The overall results of the average summary effect size the influence the discovery learning model on student learning outcomes in material units are in the Table 4.

Table 4. The data of the average of the summary effect size on learning material units

| Unit Material | N | M | SEM | Category | p | =0.05 | |
|---------------------|---|-------|-------|-----------|-------|--------|-------|
| | | | | | | lower | upper |
| Thermodynamics | 3 | 0.849 | 0.161 | High | 0.000 | 0.684 | 1.316 |
| Classical mechanics | 7 | 0.891 | 0.215 | High | 0.000 | 0.470 | 1.312 |
| Electronics | 3 | 1.032 | 0.648 | High | 0.000 | -0.239 | 2,302 |
| Fluid mechanics | 9 | 1,196 | 0.241 | Very high | 0.000 | 0.724 | 1,669 |

Based on the table above, there are 4 units of material with 3 articles on thermodynamics, 7 articles on classical mechanics, 3 articles on electronics, and 9 articles on fluids. The effect size obtained is 0.849 for the

unit of thermodynamic material, 0.891 for the unit of classical mechanics material, and 1.032 for the unit of electronic material. In these three material units, the effect size belongs to the high category. Meanwhile, the fluid mechanics material unit has an effect size of 1,196 which belongs to the very high category. In the processing of this learning material unit, a 95% confidence interval ($\alpha = 0.05$) is used which has a range, namely the thermodynamics material unit from 0.684 to 1.316, classical mechanics material unit from 0.470 to 1.312, electronics material from -0.239 to 2.302, and fluid mechanics materials from 0.724 to 1.669. The results of testing the null hypothesis or p-value test found that $p < \text{then } h_0$ was rejected, so it can be stated that the use of discovery learning modeling affects student learning outcomes in the unit of learning material. The use of the discovery learning model in the learning unit is more effectively used in the fluid mechanics material unit.

This research was conducted to decide the effectiveness of use of discovery learning models in senior high school physics learning on student learning outcomes. The influence is seen in the aspect of knowledge and on several moderator variables. The moderator variables in this study are grade level and learning materials. In determining the effect, it is necessary to calculate the effect size. Effect size is data that can show the magnitude of the strength of the relationship between two variables, through information from various summary results. By determining the effect size in each of these studies, the magnitude of the effect of a treatment can be determined.

The model of discovery learning is the model that involves students actively in learning so that student learning outcomes have increased. The increase in students' learning result is base on the ability of students to understand learning with concepts that they directly find. This is also obtained in the first results of this study, which is shown in table 2, the effect size on aspects of student knowledge is in the high category where this shows that use of the discovery learning has the significative effect on improving student learning outcomes. Students can develop knowledge with their understanding. This result is also in line with Asrizal (2018) statement, applying an effective learning model to learning activities can improve the three aspects of competence. The statement of Hosnan, (2014) through discovery learning students can play an active role in investigating and trying to solve the problems themselves [3]. Iswati and dwikoranto, (2015) also stated that students gave a good response by using the model of discovery learning, besides the model of discovery learning can affect the improvement of students' learning result [28]. So discovery learning model is effectively applied to physics learning to improve students' learning result in the knowledge aspect. Moreover, the model of discovery learning can affect the improvement of student learning outcomes. So that the model of discovery learning is effectively applied to physics learning to improve students' learning result in the knowledge aspect. In addition, the model of discovery learning can affect the improvement of student learning outcomes. So that the model of discovery learning is effectively applied to physics learning to improve students' learning result in aspect of knowledge.

The results of the second research show in table 3 a significant influence on student learning outcomes at each grade level, namely in class X and class XI are in the high category. The discovery learning model has 6 steps, namely simulation, identification of problem, data collection, data processing, proof, then concluding. The steps of the model of discovery learning can make students easy to develop their understanding. Students' understanding is influenced by the continuous learning process. The learning process that has lasted longer will have a higher understanding and learning experience. This is in line with the understanding of students at each grade level.

Furthermore, the results of the research effect size student learning outcomes based on material units. In the learning material unit, the research results are in two categories, namely high and very high. In the high category, the material unit in question is an effect size of 0.849 for thermodynamics, 0.891 for classical mechanics, and 1.032 for electronics. The very high category is the unit of fluid mechanics material with an effect size of 1,196. These results signify that the model of discovery learning affects student learning outcomes that are more effectively applied to fluid material units. These results are in agreement with the statement by research Harianto (2016) about the student learning outcomes increase using PhET-assisted discovery learning [29]. Other researchers Syahputri, A., & Delina. (2016) stated that student learning outcomes were better on dynamic fluid material using the discovery learning model[9]. Sari, D. P., & Simanjuntak, M. P. (2016) also stated that the model of discovery learning strongly supports students' physics problem-solving abilities on the subject of fluids[10]. This is due the discovery learning model requires students for make discoveries about a concept. So it can be concluded that the model of discovery learning in the material unit has a significant effect on student learning outcomes.

This research has some limitations in its implementation. The limitations that exist during the research process are expected to serve as lessons for the future. Some limitations in the implementation of meta-analysis research, namely, the journals used in this study were not too many, only limited to 7 journals. The journal consists of 6 national journals and 1 international journal with 22 articles. The article used discusses the effect of the discovery learning model on student learning outcomes. The learning outcomes analyzed in this research is only on the knowledge aspect. This is because it is difficult to find articles that can cover all three aspects of learning outcomes and the limited time in analyzing journals. From several articles found discrepancies in the

content of the article with the title of the study, where many studies have the title of influence but there is no big influence on the research. In addition, the data in the article is not all in the form of numbers. Most of the articles only said that the model of discovery learning was effective in learning activity but did not include supporting statistical data. Alternative solutions for researchers should be designed before conducting research as well as possible so that research produces perfect results.

IV. CONCLUSION

Sourced from the result of this research obtained, the model of discovery learning is effectively used in physics learning on students' learning results. The model of discovery learning applied to the knowledge aspect gives an influence that is with an effect size of 0.196 in high category. At the grade level, the discovery learning model is more effective in class XI than class X with an effect size of 0.949. While in terms of the unit of learning material, the discovery learning model is more effectively applied to unit of fluid mechanics material with an effect size of 1,196. So, the conclusion is the discovery learning model is very supportive for student learning outcomes in high school physics learning.

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