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META-ANALYSIS OF THE EFFECT OF USING PROBLEM SOLVING MODELS TO PHYSICS STUDENT ACHIEVEMENT

Dea Widya Sari[1], Hufri[1*]

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

Corresponding author. Email:hufri2020@yahoo.com

ABSTRACT

Learning models is one of the factors that affect student learning outcomes. One of the existing learning models is the problem solving learning models. There has been much research that looks at how the impact of problem solving models, but there has been no research that concludes how the impact of problem solving models on student learning outcomes. Therefore, meta-analysis methods are used. Meta-analysis is a method that analyzes some of the most important similar articles to conclude. This research purpose to decide the summary effect (M) of the impact of the use of problem solving models on high school physics learning on student learning outcomes and to determine the summary effect of the impact of the use of problem solving models on high school physics learning on student learning outcomes pursuant to subject matter. The sample in the study was twenty one articles from national journals. The result of this study is that there is an impact of the use of problem solving models in high school physics learning on student learning outcomes with a summary effect (M) of 0.812 which is in the high category and the second result is the application of problem solving models in high school physics learning has the highest influence on the kinematics motion material class x with a summary effect (M) of 1,670 which is in the very high category.

Keywords : Meta-analysis; Problem Solving; Learning Outcomes; Physics Learning

I. INTRODUCTION

Education is one of the keys to the progress of a country and the welfare of the people in the country. Because if the people in a country have tasted and have gone through education then the community will grow and develop into a complete personality and there will be a change in the mindset and behavior of the people in the country. A good education in a country, it means that the country already has future assets that determine the progress or retreat of the country [1].

One way to improve education in a country is through the learning process. The learning process is an interaction that is carried out and that occurs between learning resources and students to be able to reach the educational goals that have been set [1]. As stated in UU No. 20 of 2003 regarding the National Education System, the purpose of education is to expand the potential of students to become capable, believers, independent, creative, and become democratic and responsible citizens [2].

Whether or not educational goals are achieved can be viewed from student learning outcomes after the learning process is implemented. Learning outcomes are outcomes that a person gets after undergoing the learning process. There are three forms of student learning outcomes according to Bloom's taxonomy: 1) Cognitive domain, namely the realm of knowledge that includes aspects of memory or the introduction of certain facts, procedural patterns, and concepts that allow for the development of students' intellectual abilities and skills [3] 2) Affective domain, which includes the behavior or attitudes that emphasize the emotional and emotional aspects of students such as how to adapt, interests, attitudes, appreciation, and motivation in learning activities [4] 3) Psychomotor domain, namely aspects that contain behaviors that emphasize the motor skills of students such as the results of typing, writing and how to operate or use a tool [3]. To improve learning outcomes, one of the efforts made by the governments is to update the curriculum according to the demands of the times. To improve the quality and learning outcomes of students apart from government assistance, the role of educators is also one of the important things in order to get learning outcomes as expected [5]. One of the efforts that can be made by educators to improve student learning outcomes is by choosing the right learning model, which is following the curriculum, and the demands of the times can improve and optimize students' reasoning abilities.

One of the learning models developed by experts is the problem solving model. Problem solving learning model is a learning model that can be used so that the learning process takes place effectively so that it can improve student learning outcomes [6]. Problem solving learning model is a student oriented learning object that trains students to be able to face and find a way out of the problems they face through a systematic thought process [7]. Problem solving model is a learning model which in its application has student centered characteristics. Problem solving learning models can grow students ability to solve problems and can help students to think logically, critically, and systematically by confronting students with problems that must be solved by them [7]. Problem solving learning model is a learning model that can drive students to think because this learning model is a method of thinking where the process starts from looking for data to concluding so that students can take meaning and live their daily lives more [4,6].

Research on the impact of using problem solving models in physics learning has been done a lot, but the problems in the learning process are still not resolved. Which is still not following the reality that occurs in the field with the expected ideal conditions. The first fact is that students learning outcomes in physics are still low [5, 7, 8, 9]. This is evidenced by the result of learning physics students who reach the minimum completeness criteria of less than 50% [6]. In semester exam results there are still many students who are below the minimum completeness criteria [8] and it can also be seen in the average high school physics learning outcomes at the national level in 2019 based on the National Competence Test is 46.47 [10]. The low student learning outcomes can be caused because there are still many students who don't like physics, think physics is a difficult subject and there are too many formulas [7]. As well as the mindset of students who are not yet critical in solving problems [1].

Second fact that occurs in the field is the low interest of students in solving problems [1]. This is because in learning physics students tend to only memorize formulas without knowing the concepts and meanings [7, 11]. In the learning process, if students are faced with problems, they face and solve them as they are, regardless of the truth of the problem solving they are doing [5]. So that students reasoning abilities are not trained, students become a difficulty in understanding concepts and difficulties in solving problems faced by them [6]. This shows the low interest of students in understanding concepts and using their reasoning to solve problems.

Third real situation that occurs is that the physics learning process is still teacher-centered, less involving students to interact and participate actively in the learning process [1, 5, 12]. This can cause students to be passive in the learning process, make students lazy to think, and make students reluctant and even afraid to ask questions and express the ideas that are in their minds [1, 8, 12]. The learning process should be student-centered while a teacher can take on the role of a facilitator and assist students in learning [13].

Based on the review that the author has done on 21 articles that have met the criteria, the authors found the impact of using problem solving models in high school physics learning in each article has different research results. Therefore, users and readers of the research results will question how the final result of the problem solving model influences students physics learning outcomes. Therefore, the researcher wants to combine every information and data in each article to be able to do statistical calculations and conclude the summary effect size value which states the impact of using problem solving models in physics learning on student learning outcomes using meta-analysis research methods. This meta-analysis research method is a method that uses a quantitative approach that is carried out systematically with statistical techniques to obtain accurate conclusions from existing studies. Meta-analysis is part of the systematic review method and is included in the methodology of synthesizing research results using quantitative techniques, while the systematic review method using qualitative techniques is also called meta-synthesis. In the meta-analysis method, it is necessary to calculate or analyze the effect size where the purpose of using this effect size is to obtain an assessment of the result of research or articles being studied. Effect size (d) is the difference in the incidence of effects that occur between the experimental group and control group. So, the effect size (d) is a measure that shows how much influence a variable has to see the significance of the research result. The purpose of meta-analysis research is not much different from other types of research, namely, to determine the strength or magnitude of the difference between one variable and another, the second to conclude the data in several articles studied, and the third to control the confronting variables so as not to change the statistical meaning of the relationship or difference between variables. Therefore pursuant to explanation that has been described, research using the meta-analysis method is interesting to study to see the impact of using problem solving models in learning physics on student learning outcomes. Therefore, the title of the research that the researcher adopted is "Meta-analysis of the Effect of Using Problem Solving Models in High School Physics Learning on Student Learning Outcomes".

II. METHOD

Based on the problems that have been described previously, this research is research using the meta-analysis method which is a type of quantitative research with statistical techniques. This meta-analysis method is a method that examines several previous articles of the same type. This meta-analysis method helps researchers to find consistency or inconsistency in reviewing several research results [14]. Research data were obtained from several articles through the google search engine like 1) iSinta Indonesia 2) Google Scholar 3) *Publish* or perish application 4) Proceedings and journals from various institutions and universities in Indonesia 5) IOP Journal 6) National Library of Indonesia 7) Scimago Journal 8) DOAJ 9) Research Gate 10) Sciencedirect 11) Garuda Journal and others. To facilitate the research for articles, keywords such as "problem solving", learning models", "learning outcomes", and "physics education" are used. The data that have met the criteria for use in this study are 21 articles from national journals.

In this meta-analysis, the articles used are articles that meet criteria such as 1) The articles selected are research articles that have the same topic. 2) The articles used in this study are the latest published articles 3) The articles used are articles that have the necessary statistical data. The variables used in this study are the independent variable, dependent variable, and moderator variable. Variables are everything determined by researchers who will be studied and will be researched so that they can obtain information and conclusions from these variables [15]. The independent variable in this study is a problem solving learning model, the dependent variable is student learning outcomes and the moderator variable is learning material. According to Sugiyono (2012), sources of data used in the study are divided into two, namely primary data and secondary data. Primary data is data obtained directly from the data source, researchers directly get data from the main source or get data from the location or object of research and secondary data is data is not directly obtained from the data source. In this study, the type of data used is secondary data, because the data were obtained from the results of research in previous articles from a few journals.

They are seven procedures must be carried out in meta-analysis research: 1) Determine the problem or topic to be researched. The problem to be investigated in this study is the impact of using problem solving models in high school physics learning on student learning outcomes. 2) Set the period of the research results to be used. In this meta-analysis, secondary data from previous research is used, so it is necessary to set the period of the research results used. The period used in this study is from 2011 to 2022 3) Do an article search. In conducting article searches, it is necessary to adjust the characteristics of the articles that have been determined, and to facilitate the search for articles it is necessary to use keywords or keywords 4) Focus on research. Focusing research needs to be done to get better results. The research is focused on research methodologies such as the type of research, research criteria, research variables, research steps, data analysis techniques, and research results. 5) Categorize articles. All articles that have been obtained are grouped based on the moderator variable in this study's subject matter 6) Carry out qualitative and quantitative analysis of the entire article. Quantitative and qualitative analysis of all articles was carried out to obtain further information and to bring up moderator variables and quantitative data needed to calculate effect size 7) Perform data analysis and draw conclusions. After conducting qualitative and quantitative analysis of all articles that have met the criteria, data analysis can be carried out, starting from calculating effect sizes to summary effects and drawing conclusions to be reported as scientific research. If all the statistical data needed in the meta-analysis research has been collected, the data analysis can be carried out.

The data analysis technique in this meta-analysis is the effect size analysis technique. The data analysis stages can only be carried out after all the statistical data needed in the meta-analysis research has been collected. There are several types of meta-analysis research including pre-post contrast meta-analysis and group contrasts meta-analysis. In this study, the researcher used a contrast group meta-analysis, which is a type of research that involves one or more variables that are measured in two or more groups of respondents and then compared. The following are the steps of data analysis carried out in the contrast group meta-analysis study:

A. Perform effect size calculation
   1. If only the posttest test that carried out for the two sample groups, then the effect size equation can use the posttest average value of the control group, the posttest average of the experimental group and the standard deviation of the control group, like the first equation below:

$$d = \frac{Xeks - Xcon}{SDcon} \qquad (1)$$

2. If all statistical data from two sample groups in a study is known, then the effect size value can be calculated using the following equation:

$$d = \frac{(Xpost - Xpre)E - (Xpost - Xpre)C}{\frac{SDpreC + SDpreE + SDpostC}{3}} \qquad (2)$$

3. If the statistical data from the experimental class and the control class are incomplete, such as the standard deviation and the average value of the posttest or pretest is unknown, then the effect size value can be calculated using the t-test equation below:

$$d = t\sqrt{\frac{1}{Neks} + \frac{1}{Ncon}} \qquad (3)$$

(Source: Ref [16])

B. Calculate Summary Effect (M)

After obtaining the effect size value, the next step of analysis is to calculate the summary effect value to find out a summary or description of the effect size to be observed. They are two summary effect models that use in this data analysis, namely Fixed Effect (FE) and Random Effect (RE).

1. Fixed Effect Model (FE)
   The fixed effect [FE] model is used when the populations of several analyzed articles are identical or functionally equivalent. The purpose of the analysis is to draw effect size conclusions based only on the identified population [17].
2. Random Effect Model (RE)
   The random effect [RE] model is used when the population of the analyzed articles differed functionally due to the treatment given [17].

C. Result Interpretation

After calculating the summary effect value, the calculation results that have been obtained are interpreted into several categories as shown in table 1 below.

Tabel 1. Effect Size Category

Effect Size	**Category**
d ≤ 0,15	be ignored
0,15 < d ≤ 0,40	small
0,40 < d ≤ 0,75	currently
0,75 < d ≤ 1,10	high
d > 1.10	very high

(Source: Ref [18])

III. RESULTS AND DISCUSSION

After going through the article search stage, quantitative and qualitative analysis of articles, calculating effect sizes, grouping articles based on dependent and moderating variables, and calculating summary effects, the final results of this research will be obtained. The final outcome from this research is to see impact of using problem solving models in high school physics learning on student learning outcomes and to see the impact of problem solving model in high school physics learning on student learning outcomes based on learning material. This result can be reviewed from the value of the summary effect (M) calculation that has been done. Data calculations are carried out using the help of the Microsoft Excel application. The effect of problem solving model in high school physics learning on student learning outcomes is explained in the following data.

A. Summary Effect (M) of Problem Solving Models on Student Learning Outcomes in Cognitive Aspects

The result of the first research is on student learning outcomes. To decide the imfluence of using problem solving models in physics learning on student learning outcomes for cognitive domain, it can be seen in the results of the calculation of the summary effect (M) from 21 articles. In this study, the learning outcomes analyzed were only on the cognitive aspect, due to the unavailability of data on affective and psychomotor learning outcomes in the analyzed articles.

Table 2. Data from the Summary Effect (M) of the Influence of Problem Solving Model on Student Learning Outcomes in Cognitive Aspects

N	M	SE_M	Category	Z	P	α = 0.05	
						LL_M	UL_M
21	0.812	0.092	high	8.820	0.000	0.632	0.993

The confidence interval of the above data is 95% from 0.632 to 0.993. The influence of problem solving model on student learning outcomes has an effect size of 0.812, this indicate that the effect of the problem solving model is in the high category. The results of the two-tailed test obtained are 0.000 where $p < (0.05)$ then the results of testing the null hypothesis are rejected. This proves the influence of the use of problem solving model on student learning outcomes in the cognitive domain. This is due to the characteristics of student-centered problem solving models that train students to think from diagnosing problems to solving problems, so that students' thinking skills can increase which also affects students' cognitive learning outcomes and because applying problem solving models it can guide students. to be independent in solving problems faced by him so that it can bring up the shrewdness and skills of students in answering physics questions [4]. Learning outcomes using problem solving models were higher than learning outcomes using conventional models [19].

B. Summary Effect (M) of the Influence of Problem Solving Model on Student Learning Outcomes Based on Subject Matter

The outcome of the second research is the influence on student learning outcomes pursuant to learning materials. In physics learning there are several topics of material studied starting from class x, xi, and xii but of the 21 articles that meet the criteria, only 18 articles mention the material tested to students. Based on all the articles used in this meta-analysis, there are 10 kinds of learning materials applied. Summary effect values for dynamic electrical materials, simple harmonic motion, and motion kinematics were obtained using a random effect model, while heat, quantities and units, ideal gases, work and energy, optics, momentum and impulses, and static fluid models were obtained using the fixed effects model. The results of data processing summary effects of the impact of problem solving model on student learning outcomes pursuant to learning materials can be seen in the following table:

Table 3. Data Summary Effect of the Impact of Problem Solving Model on Student Learning Outcomes Pursuant to Learning Materials

Theory	N	M	SE_M	Category	Z	P	α = 0.05	
							LL_M	UL_M
Dynamic electricity class x	4	0.868	0.160	high	5.435	0.000	0.555	1.180
Static fluid class xi	2	0.950	0.194	high	4.887	0.000	0.569	1.331
Simple harmonic motion class x	2	0.825	0.337	high	2.451	0.014	0.165	1.485
Motion kinematics class x	3	1.670	0.294	very high	5.679	0.000	1.093	2.246
Momentum and impulse class x	2	0.571	0.180	medium	3.169	0.002	0.218	0.923
Optics class x	1	0.617	0.321	medium	1.925	0.054	-0.011	1.246
Work and energy class x	1	0.633	0.236	medium	2.689	0.007	0.172	1.095

ideal gas class xi	1	0.602	0.262	medium	2.294	0.022	0.088	1.116
Quantity and unit class x	1	0.323	0.324	small	0.998	0.318	-0.311	0.957
Heat	1	0.523	0.261	medium	2.004	0.045	0.012	1.035

From the table above it can be seen that physics material that has the highest influence from the use of problem solving models is class x motion kinematics with an effect size value of 1,670 with a 95% confidence interval ($\alpha = 0.05$) ranging from 1,093 to 2.246. This is following the results of research obtained by Nuriana (2018) which states that problem solving learning models have a positive impact on improving student learning outcomes in motion kinematics material. Because the motion kinematics material requires the ability to analyze to solve problems, then the use of problem solving models is the right thing [15]. The material that has the least effect from the use of problem solving models on learning outcomes is the material of quantity and unit with an effect size value (d) of 0.323. the effect size (d) for dynamic electrical material is 0.869, for static fluid material 0.950, simple harmonic motion material is 0.825 which is in the high category, and effect size for momentum and impulse material is 0.571, the optical material is 0.617, work and energy are 0.633, for material ideal gas is 0.602 and for heat material with an effect size of 0.523 these five units of material have an effect size that is in the medium category. The results of testing the null hypothesis or p-value test obtained p < values for dynamic electrical material units, static fluids, simple harmonic motion, motion kinematics, momentum and impulses, optics, work and energy, ideal gases, and heat which means H_0 is rejected and proven that the problem solving model influences student learning outcomes for the material unit. However, for the material unit and quantity class x, the results of the p-test (0.318) > α (0.05) which means that there is no impact of the problem solving model on student learning outcomes for the material unit of quantity and unit class x.

C. Summary effect of the impact of problem solving models with additional assistance on student learning outcomes

The third outcome of this study is a summary effect (M) of the effect of problem solving models with additional assistance such as learning media and teaching materials on student learning outcomes. In the results of this third study, there were five articles analyzed. Summary effect calculation is done by using the random effect model. The following are the result of calculating the summary effect of the effect of the problem solving model with additional assistance on student learning outcomes.

Table 4. Data from the summary effect (M) of the influence of the problem solving model with additional assistance on student learning outcomes

N	**M**	**SE_M**	**Category**	**Z**	**P**	**$\alpha = 0.05$**	
						LL_M	**UL_M**
5	1.341	0.421	very high	3.182	0.001	0.515	2.166

Pursuant to the table of the results of the summary effect (M) calculation above, the effect size of the problem solving model with additional assistance on student learning outcomes is 1.341 with a lower limit of 0.515 and an upper limit of 2.166 which is included in the very high category. By using a 95% confidence interval ($\alpha = 0.05$) and p-value < α test results, H_0 is rejected, which means that there is an effect of problem solving model with additional assistance on student learning outcome. However, the effect of using the problem solving model with additional assistance will provide different results depending on the type or quality of assistance used, such as media, teaching materials like worksheet, and so on.

IV. CONCLUSION

The use of problem solving models has an influence on student learning outcomes in the cognitive aspect, this is evidenced by the results of the summary effect calculation with a value of 0.812 which is in the high category. Than the use of problem solving models in high school physics learning has a significant effect on class X kinematics material as evidenced by the summary effect value of 1.670 which is included in the very high category and after testing the null hypothesis the problem solving model has no effect on student physics learning outcomes on material quantities and units with this can be proven by the summary effect value of 0.323 which is included in the small category. Finally the effect of the problem solving model with additional assistance influences student learning outcomes with a summary effect value of 1.341 which is included in the very high category.

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