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Meta-analysis: The effect of means ends analysis learning model on students' mathematical problem-solving ability

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ABSTRACT

This study aimed to determine the effect of using the MEA learning model on improving students' mathematical problem-solving abilities. The MEA learning model is a model that teachers can use to improve students' problem-solving abilities. This research is meta-analytic, namely by collecting data from previous researchers and then finding the effect size *of all the data that has been obtained. Many of the data points found that match this research have met the criteria when searched using Google Scholar with the specified keywords. This research analysis tool uses SPSS software version 29.0 and uses the Cohen formula in data analysis. The finding of* the effect size *of the entire data is 1.431, which is categorized as having a considerable influence. Based on moderator variable analysis, the number of samples with $n > 31$ showed a larger effect size than $n < 30$. Furthermore, based on the level of education of junior high school students, it has an effect size that is categorized as having a large influence. This meta-analysis study shows that using the MEA learning model affects students' mathematical problem-solving abilities.*

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INTRODUCTION

According to the National Council of Teachers of Mathematics (Barham, 2020), one of the principles and standards for school mathematics is identifying problem-solving as one of the process standards that students need to achieve. Students learning mathematics must possess problem-solving abilities. Therefore, students' problem-solving abilities must continue to develop. Problem-solving is applying experience, knowledge, and skills to solve problems in new situations to achieve specific goals (Mariani & Susanti, 2019; Palupi, Suyitno, & Prabowo, 2016; Wahyudi & Anugraheni, 2017).

In addition, practicing problem-solving also requires specific learning methods. Difficulties in life and calculations are complicated. Solving a problem requires a thorough understanding of cause and nature, the right plan, proper execution, and the revision of the results. The ability to solve mathematical problems is a complex skill that needs to be taught carefully to students. Therefore, the learning methods used in developing mathematical problem-solving skills must also be supportive of letting students learn mathematics with the opportunity to practice problem-solving (Yapatang & Polyiem, 2022).

In the Program for International Student Assessment (PISA) study organized by the Organization for Economic Co-Operation and Development (OECD), Indonesia ranks 71st in mathematics ability among the 77 countries that have joined, and 71% more Indonesian students occupy levels 1 and below. According to the National Council of Teachers of Mathematics 2000 (Syafri, 2017), the knowledge, understanding, and skills that students must possess are included in the process standard, which includes mathematical problem-solving, reasoning, and mathematical proof, mathematical communication, mathematical connection, and mathematical representation. These five principles are things that students must achieve in mathematical ability. From this statement, problem-solving ability is one of the abilities that must be possessed by students so that they can solve given mathematical problems.

The model used in the learning process influences students' problem-solving abilities. Improving students' problem-solving abilities can be developed using innovative models and approaches and by providing opportunities for students to actively participate in solving mathematical problems (Wulandari, Dantes, & Antara, 2020). One model that teachers can use to help students' problem-solving abilities is the Means Ends Analysis (MEA) learning model. The MEA learning model can be understood as investigating a problem to achieve specific goals. In solving problems, students must understand concepts that are more meaningful to them so that they can develop problem-solving abilities.

MEA learning is learning using a problem-solving approach to solving a given condition. The approaches in the MEA model, according to Sahrudin (as cited in Haryanti (2018)), are: 1. Identify the differences between current conditions (the current state) and goals (the goal state); 2. Arrange subgoals to reduce these differences; 3. Please choose the correct operator and apply it correctly so that the subgoals that have been prepared can be achieved.

METHOD

This study uses meta-analysis to find articles that broadly and accurately relate the MEA learning model to students' mathematical problem-solving abilities. A meta-analysis combines and evaluates data from several research articles investigating and testing conceptual and hypothetical study topics. Meta-analysis is a set of statistical methods for correlating the quantitative results of multiple researchers to produce an overall summary of empirical knowledge on a given topic (Puspitasari & Airlanda, 2021).

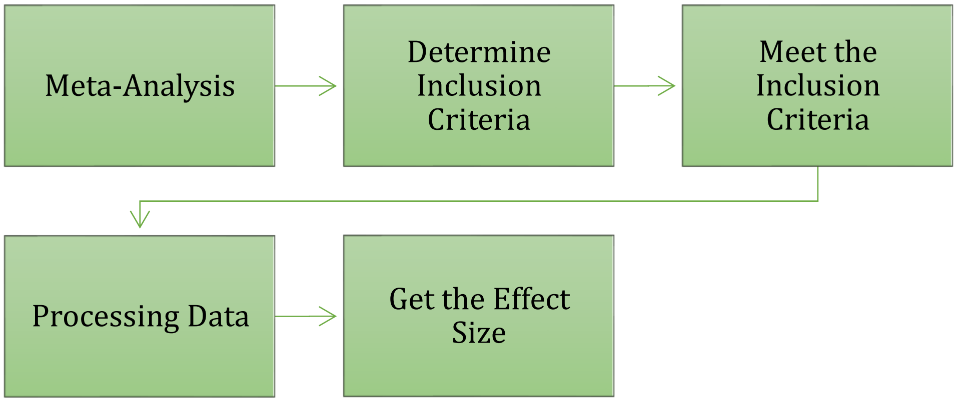

Figure 1. Research Design

Data collection in this study was carried out by searching for articles online using Google Scholar with the keywords "problem-solving ability" and "model means-ends analysis". There are five stages to conducting this research: first, determining the problem or topic to be studied, namely the effect of the MEA learning model on students' mathematical problem-solving abilities. Second, find and collect research reports in the form of national journals and articles related to the problem or topic to be studied and determine the period of the research meeting that will be used as the data source, namely published in 2015–2022, so that the data source used is the latest research conducted by previous researchers. Third, read the research report to see the suitability of the content for the specified problem, focus research on the problem in the form of aspects of research methodology, and categorize each study. Fourth, determine the magnitude of each research report's effect (effect size) from the data obtained. Fifth, to analyze published research reports based on a review of the methods and data analysis used so that conclusions can be drawn from the meta-analytic research conducted. The data analysis technique used in this research is the effect size analysis technique. The effect size formula used in this study is the Cohen formula. The criteria used to interpret the effect size refer to Cohen (Paloloang, Juandi, Tamur, Paloloang, & Adem, 2020) as follows:

Small effect	$:< 0.2$
Moderate effect	$:0.2 < \Lambda \leq 0.5$
Big effect	$:0.6 < \Lambda \leq 1.3$
Huge effect	$:> 1.3.$

RESULTS AND DISCUSSION

Based on search results through Google Scholar, the researcher obtained articles that were relevant to the research study sample criteria used in this meta-analysis study. The criteria in this study were that research articles had one experimental class with the MEA model and a control class using conventional or other models. The available data consisted of sample size, mean, and standard deviation.

Table 1. The Effect Size for Each Study

ID	Study	Effect Size	std. Error	Z	Sig. (2-tailed)	95% Confidence Intervals Lower	Upper
NK Miranti	2015	.605	.2640	2.292	.022	.088	1.123
Yudha	2019	1.570	.2859	5.491	<.001	1.010	2.131
Asih and Ramdhani	2019	7.156	.6911	10.355	<.001	5.802	8.511
Supendi et al	2017	.450	.2339	1.926	.054	-.008	.909
Wulandari et al.	2021	1.271	.2621	4.851	<.001	.758	1.785
Palupy et al.	2016	1.364	.2635	5.177	<.001	.848	1.881
Sari	2020	1.322	.2950	4.482	<.001	.744	1.900
Practice	2018	.715	.2306	3.101	.002	.263	1.167
Persistence	2021	1.010	.3003	3.362	<.001	.421	1.598
Jais and Faizal	2019	.619	.3086	2.004	.045	.014	1.224
Perma	2022	.347	.2253	1.539	.124	-.095	.788

Based on Table 1, it can be seen that each study had a different effect size. The lowest effect size in this study is 0.347, which, according to Cohen, means it has a moderate effect, and the highest is 7.156, which is categorized as having a huge effect.

A heterogeneity test was carried out by examining the p-value. If $p < 0.05$, then the null hypothesis, which states that the effect size of each study is homogeneous, is rejected, so the estimate chosen is the random-effects model. If $p > 0.05$, then the null hypothesis is accepted and the fixed-effect model is used (Paloloang et al., 2020). Based on the results of the known analysis, it can be concluded that the estimation uses a random-effects model.

Table 1. Overall Result by Random-effect

	Effect Size	std. Error	Z	Sig. (2-tailed)	95% Confidence Intervals Lower	Upper	p-value
Overalls	1.431	.5253	2.724	006	.401	2.460	.01

Based on Table 2, the effect size of the entire data is 1.431 concerning Cohen, so the effect size is huge, with a standard error of 0.5253. The lowest limit of the confidence interval is 0.401, and the highest limit is 2.460, with a 95% confidence interval level. Thus, the use of the MEA learning model has a significant influence on students' mathematical problem-solving abilities.

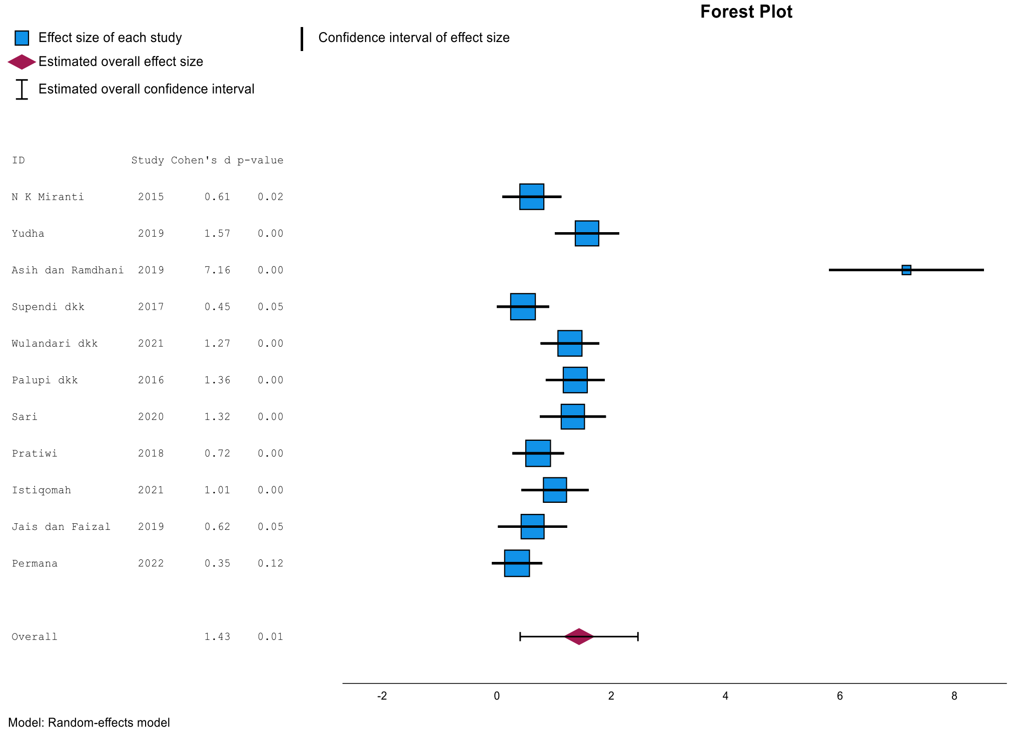

Figure 2. Forest Plot

Another meta-analysis result is the forest plot, as shown in Figure 2. The effect size refers to the studies in this study; the smallest effect size is 0.35 (Permana, 2023), and the highest (Asih & Ramdhani, 2019) effect size is 7.16. Linguistically, the statistical results of the studies related to the effect sizes indicated that all 11 studies that made up the sample had a positive effect. In Figure 2, studies are located to the right of the no-effect line, represented by the dotted line passing through zero. All studies show benefits for the experimental group that learns with the MEA model.

Table 3. Result of the Analysis based on the Moderator Variable

Category	Group	n	Effect Size	std. Error	Z	95% Confidence Intervals	
						Lower	Upper
Educational level	SMA	1	7.156	.6911	10.355	5,802	8.511
	SMP	9	.871	.1483	5.871	.580	1.161
	SD	1	1,271	.2621	4.851	.758	1.785
Sample size	n<30	4	.991	.2025	4.896	.594	1.388
	n>31	7	1.780	.8567	2078	.101	3.460

In Table 3, the moderator variables in this study are educational level and sample size. The results based on the educational level showed that the SMP level is the largest group, and the effect size given at this level is 0.871, so it is categorized as having a large influence. As for the SD and SMA levels, each number is one, so the effect size given cannot be ascertained. Further research is needed regarding the results of this study.

Moderator variable analysis based on sample size for sample size $n < 30$ is 0.991, so it is categorized as having a large influence. The sample size $n > 31$ is 1.780, so it is categorized as having a huge influence.

The analysis results show that the study's overall effect size is 1.431 with a huge influence category, so it can be concluded that the MEA learning model improves students' mathematical problem-solving abilities compared to conventional learning. The stages in the MEA learning model are one example of how they can hone students' abilities in solving given problems. Furthermore, if these stages continue to be applied by students, their problem-solving abilities can continue to increase (Palupi et al., 2016).

Based on an educational level, according to Paloloang et al. (2020) and Tamur & Juandi (2020), higher grades have higher engagement. The junior high school level significantly influences improving students' mathematical problem-solving abilities with the MEA model of learning. In contrast, further research is needed for the elementary and high school levels.

The results of the moderator variable analysis based on sample size have *an* effect size of $n < 30$, which is categorized as a significant influence. In contrast, for $n > 31$, it is categorized as an effect. As the results of the meta-analysis study conducted by Öksüz, Eser, & Genç (2022) and Tamur, Juandi, & Adem (2020) concluded that, "the combined *effect size* of the small sample group (30 or less) is significantly different from the combined *effect size* of the large sample group (31 or more)". At the same time, these results complement similar studies in the literature, including sample size as an analytical variable (Tumangkeng, Yusmin, & Hartoyo, 2018; Turgut & Temur, 2017). Based on these studies, the effect of a small study group on a small sample is stronger than the effect on a large sample. This is different from the findings in research of Paloloang et al. (2020); more primary studies are needed for better results in the analysis.

CONCLUSIONS AND SUGGESTIONS

The results of the analysis show that the use of the MEA learning model has an influence on improving students' mathematical problem-solving abilities and also has a positive influence on their mathematical problem-solving abilities. The results of the analysis also show that the difference in effect size is due to the sample size and education level.

When using this model, it is recommended to pay attention to the sample size and level of education so that it can work effectively.

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