Meta Analysis: The Effect of Inquiry Learning Model on Students' Mathematics Learning Outcomes

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ABSTRACT

This study aims to determine whether or not there is an effect of the inquiry learning model on students' mathematics learning outcomes. In this study there are 10 articles that will be analyzed from 2017-2024. This research is designed with a review study design that uses meta-analysis techniques. By looking for the effect size of several articles in the journal. Effect size provides information related to the strength and size of the effect of each study contained in this study. The keywords in this meta-analysis study are the effect of the inquiry learning model on student math learning outcomes. There are three levels of education, namely elementary school, junior high school / MTs, and senior high school / MA / SMK. The method used in this research is meta-analysis with a quantitative approach using OpenMEE data processing software. Based on the meta-analysis calculation, there is a relationship between all articles. Proven by the p-value < 0,001 which means the analysis is significant with sig. 0.05 and the value of I^2 above 75%. With a heterogeneity of 75.518, which means it is quite high. The inquiry learning model is effectively applied at the junior high school / MTs level, because it has an effect size of 1.126. Second, it is effective at the elementary level with a value of 0.921 and third, it is effective at the high school level with an effect size of 0.631.

Keywords: Inquiry learning model, Math learning outcomes, and Meta analysis.

INTRODUCTION

Education is any kind of learning that occurs throughout life in all places and situations and has a positive impact on the growth of each individual. Education can also be defined as *lifelong* training. Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to determine religious spiritual strength, self-control, personality, intelligence, education, education and the learning process of noble morals and skills needed by themselves and society (Bp *et al.*, 2022). Education is very necessary at this time. Education is the source of one's knowledge and insight. Education is a learning process. Learning can be interpreted as a process of change related to knowledge, attitudes, behavior, and even skills (Suharya, 2021).

Based on the 2018 PISA results, Indonesia ranked in the bottom 10 out of 79 participating countries. The average reading ability of Indonesian students is 80 points below the OECD average. Indonesian students' reading comprehension is also still lower than students from ASEAN countries. The average skills of Indonesian students in reading, math, and science are 42 points, 52 points, and 37 points lower than the average of ASEAN students, respectively (Nur'aini *et*

al., 2021). This fact can illustrate that Indonesian students' math skills are low. This can result in low math learning outcomes at school. In the learning process, sometimes teachers create a saturated learning atmosphere and make students not participate in the learning process, where in every learning process, students must be active (Dewi, Asifa and Zanthy, 2020). Based on this explanation, the problems that arise can be resolved by applying a scientific learning model (Susmariani, Widana and Adi, 2022). So to overcome this, it is necessary to use effective and interesting learning media so that students have an interest in learning seriously. Therefore, teaching mathematics with the best methods requires hard work to improve math material skills. Hopefully, students' math learning outcomes can improve (Muhati, Wenas and Runtu, 2021).

Learning models are usually based on different principles and theories. Learning models are usually based on learning theories that are divided into four groups as much as learning models. This model serves as a general pattern of learning behavior to achieve the expected learning objectives and competencies. Teachers can choose the right learning model that is effective to achieve learning objectives (Magdalena, Agustin and Fitria, 2024). One of the most important things that can be done to prepare for future success in the era of globalization is education. School education is one of the many ways to obtain education. The learning model is expected to not only help students understand the material, but also improve student learning outcomes by using the scientific method. The learning model used is the inquiry learning model (Listyaningrum, 2024).

The inquiry-based learning model aims to innovate the student learning process. The use of the inquiry model causes learning activities to be more enjoyable and ultimately affects the understanding of the concepts found. Basically, the purpose of inquiry-based education is to enable students to formulate questions and seek answers and solutions to satisfy their curiosity and support their theories and ideas about the world (Juniati and Widiana, 2017). Furthermore, inquiry learning is said to aim to develop the level of thinking and critical thinking skills. Critical thinking skills include examining, connecting and evaluating all aspects of the focus of a problem, collecting, organizing information, validating, analyzing information, remembering, connecting previously learned information, and determining reasonable and valid answers (Widodo, 2010). Critical thinking is an advanced thinking skill that requires a person to solve a problem logically and accurately (Rohmah, Widodo and Katminingsih, 2022). The inquiry learning model is a learning model that makes students the subject. Students perform various activities to discover new concepts (Nurhidayah, Samad and Hartono, 2019). The inquiry learning model is a learning model that makes students the subject of the activity. Students carry out various activities to find new concepts (Susila, Wiarta and Agustika, 2023). Inquiry is a learning method that requires students to be more active in the discovery process, participate more in self-learning and activities, and solve problems (Nurdalilah, 2020). So it can be concluded that this inquiry learning model requires students to be more active in the learning process. This inquiry learning model can develop key skills that can be transferred into students' daily work and life, such as critical thinking, problem solving, research, creative thinking, innovation, communication, work and high literacy using technology as a learning tool (Adrian *et al.*, 2022). Meanwhile, learning outcomes are changes in overall behavior, not just one aspect of human potential (Ardianto, Mulyono and Handayani, 2019).

Based on previous research, it can be shown that the inquiry learning model affects students' mathematics learning outcomes (Hartatik, Hikmah and Azmi, 2022). Thus, it can be seen that many studies that discuss the inquiry learning model on student learning outcomes have a great influence. So that

researchers will conduct research related to "Meta Analysis: The Effect of the Inquiry Learning Model on Student Mathematics Learning Outcomes". Researchers used 10 articles to be analyzed in this study.

RESEARCH METHODS

This type of research is a meta-analysis, using a quantitative approach. Meta-analysis is quantitative, because it uses numerical and statistical calculations to find practicality, namely collecting and extracting information from large data sets, which is not possible with other methods (Putri, 2020). Meta-analysis is a review of the results of similar and previous studies (Christian, 2021). Meta analysis is a method carried out by summarizing the results of several studies contained in articles and is quantitative in nature (Listyaningrum, 2024). Meta analysis can also mean that the analysis is carried out systematically from previous research using known statistical data such as the number of samples (N), the average or mean, and the standard deviation (SD) of each group, namely the experimental group and the control group.

The study to be analyzed is related to the effect of inquiry learning model on students' mathematics learning outcomes. There are 10 articles indexed by national journals and data from thesis results that have met the inclusion and exclusion criteria. The following table presents the inclusion and exclusion criteria.

Table 1. Inclusion and Exclusion Criteria

No.	Inclusion Criteria	Exclusion Criteria
1.	National articles and thesis data indexed by Google Scholar and related to the effect of the inquiry learning model on student math learning outcomes.	Articles that are not full text.
2.	Article with experimental research methods.	Articles that do not use experimental research methods.
3.	Articles that have a writing time span of the last 7 years (2017-2024).	Articles that fall under the 2017 timeframe.
4.	Articles that contain information in the form of statistical data such as the average or mean value, standard deviation and the number of samples from the experimental class and control class.	Articles that do not contain information in the form of statistical data such as the average or mean value, standard deviation and the number of samples from the experimental class and control class.

Basically, the purpose of meta-analysis research is to combine, then synthesize, and finally analyze statistically and systematically (Amelia *et al.*, 2022). The data analysis technique used in the meta-analysis is the value of the effect size (Wahyuni and Astuti, 2021). So effect size is an important element in meta-analysis research. Meanwhile, to find research data to be analyzed, it is sourced from Google Scholar (Tamur *et al.*, 2022). For meta-analysis research using the PRISMA (*Preferred Reporting Items for systematic review and meta-analysis*) method (Juandi, Kusumah and Tamur, 2022).

Furthermore, all data will be analyzed and statistically calculated. According to (Wardhani, 2020) suggests that the steps of meta-analysis are as follows (1) identifying research problems; (2) collecting data; (3) coding all primary studies that have been determined; (4) conducting statistical analysis (publication bias test, effect size calculation, heterogeneity test, and estimation model, hypothesis testing, study characteristics test); (5) and presentation of research results. The source of study data is from 2017-2024, with certain criteria. The data is presented in the following table.
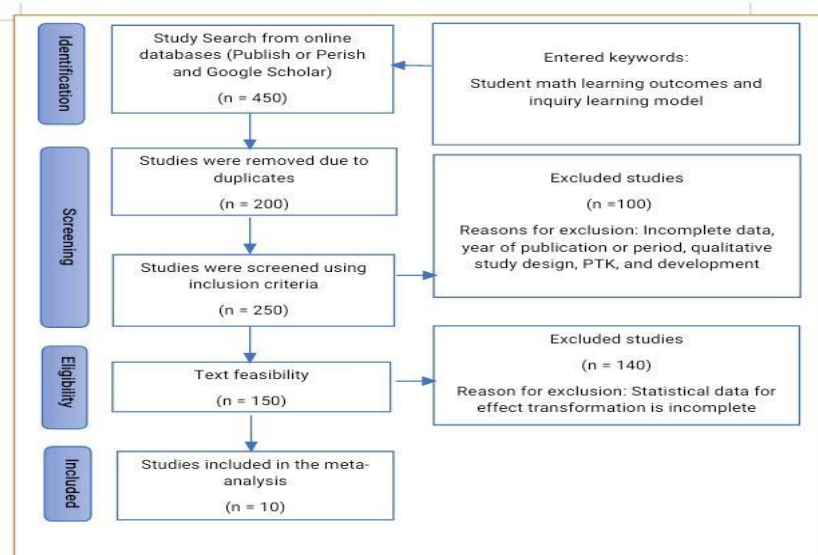
Figure 1. Research Procedure

Table 2. List of articles used in the study

No	Code	Author	Publication Type
1	AB01	Oktavia Muhati, John. R. Wenas, dan Patricia V. J. Runtu.	MARISEKOLA: Jurnal Matematika Riset Edukasi dan Kolaborasi. Vol. 2 No. 1., 2021
2	AB02	Nurhidayah, Irfawandi Samad, dan Resky Hartono.	PEPATUDZU: Media Pendidikan dan Sosial Kemasyarakatan. Vol. 15 No. 2., 2019
3	AB03	I Gede Darma Susila, I Wayan Wiarta, dan Gusti Ngurah Sastra Agustika.	Mimbar Pendidikan Indonesia. Vol. 3 No. 1., 2022
4	AB04	Adrian, Hasan Maksum, Mukhlidi Muskhir, dan Riki Mukhaiyar.	VOX EDUKASI: Jurnal Ilmiah Ilmu Pendidikan. Vol. 13 No. 2., 2022
5	AB05	Debora Aprilihona Saragih, Lasman Malau, dan Yoel Octobe Purba.	Jurnal Pendidikan dan Konseling. Vol. 4 No. 6., 2022
6	AB06	Nurdalilah	Journal MathEducation Nusantara. Vol. 3 No. 1., 2020
7	AB07	Efriza Yanti	http://repository.uinsu.ac.id/3448/ Thesis (2017)
8	AB08	Baiq Dewi Hartatik, Hapipi, Nurul Hikmah, dan Syahrul Azmi.	Griya Journal of Mathematics Education and Application. Vol. 2 No. 1., 2022
9	AB09	Moch Nurhadi, Sri Surachmi W, dan Sri Utaminingsih.	VIVABIO: Jurnal Pengabdian Multidisiplin. Vol. 2 No. 1., 2020
10	AB10	Tri Yulia Ningrum, M. Coesamin, dan Sasmiati.	https://jurnal.fkip.unila.ac.id/index .php/pgsd/article/view/20498 Journal (2019)

RESULT AND DISCUSSION

Furthermore, all studies that have been recorded were then extracted based on the statistical data information and study characteristics required. The following is a recapitulation of the data extraction results, listed in the table below.

Table 3. Recapitulation of Data Extraction Results

Statistical Data							
Code	Experiment Group			Control Group			Education Level
	Mean	SD	N	Mean	SD	N	
AB01	70,2	10,23	20	58,38	8,2	21	SMP/MTs
AB02	78,17	13,09	24	68,81	12,47	18	SMP/MTs
AB03	0,58	0,162	37	0,35	0,153	33	SD
AB04	82,4	11	34	73,9	15	34	SMA/MA/SMK
AB05	79,22	7,84	32	60,31	10,39	32	SMP/MTs
AB06	80,56	8,45	30	75,05	8,16	30	SMP/MTs
AB07	88,87	9,06	33	80,46	6,99	32	SMP/MTs
AB08	70,529	11,39	30	63,212	11,84	30	SMA/MA/SMK
AB09	74,939	10,185	33	71,942	95,423	35	SD
AB10	0,5	0,11	33	0,25	0,25	30	SD

Table 3 presents information from 10 articles consisting of experimental and control groups. In addition, the average value (Mean), number of samples or data (N), and Standard Deviation (SD) are also known. The articles are coded AB01, AB02, AB03, AB04, AB05, AB06, AB07, AB08, AB09, and AB10. The following are characteristics based on level, namely at the elementary school level the codes AB03, AB09, and AB10. At the junior high school / MTs level the codes AB01, AB02, AB05, AB06, and AB07. While at the SMA / MA / SMK level with codes AB04 and AB08.

After this, the data that has been extracted is then subjected to a publication bias test using funnel plot and fail-safe N (FSN) test. This test aims to ascertain whether the data that has been collected can be used as a representative sample of the population. This is done by checking whether the shape of the funnel plot is symmetrical or asymmetrical. The following figure shows the effect size distribution of each study which can be checked using the *funnel plot*.
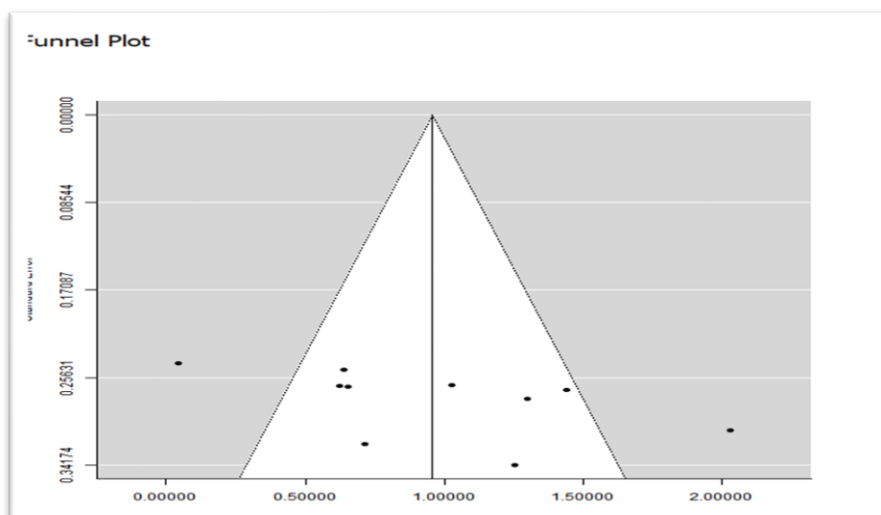

Figure 2. Publication bias test using *funnel plot*

The figure above shows the effect sizes of the 10 primary studies that have been analyzed and illustrates that the funnel plot is not symmetrical. However, it is quite difficult to conclude whether it is really asymmetrical or symmetrical. So that other publication bias tests can be carried out, for example, such as the fail-safe N (FSN) test (Retnawati *et al.*, 2018). The data will be processed using OpenMEE software.
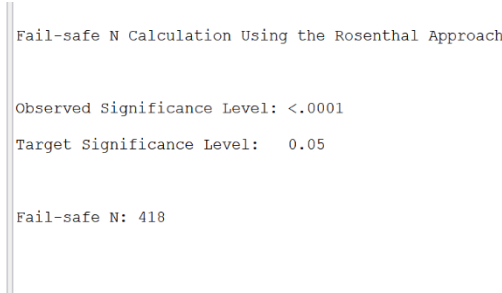
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Fail-safe N Calculation Using the Rosenthal Approach


Observed Significance Level: <.0001

Target Significance Level:   0.05



Fail-safe N: 418
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Figure 3. *Fail-safe N (FSN) test*

The figure shows the *fail-safe N* (FSN) test is an approach method suggested by Rosenthal (Hajiriah *et al.*, 2023)This is done with the aim of overcoming the problem of publication bias. Based on the results of the analysis above, it produces a value of 418. Manually it can be calculated using the formula $\frac{N}{(5K+10)}$ by substituting the value of N = 418 and K is the number of studies to be meta-analyzed, which is 10 articles, so that the result is 6.9 (more than 1). With a significance level of 0.05 and a p-value < 0,001. So it can be interpreted that the data from the 10 articles used in this study are included in the analysis that is resistant to publication bias, and are also suitable for use in further analysis. The following table shows the effect size results obtained from the OpenMEE software calculation using the Hedges'g equation. The following is a display of the effect size calculation results from OpenMEE software.
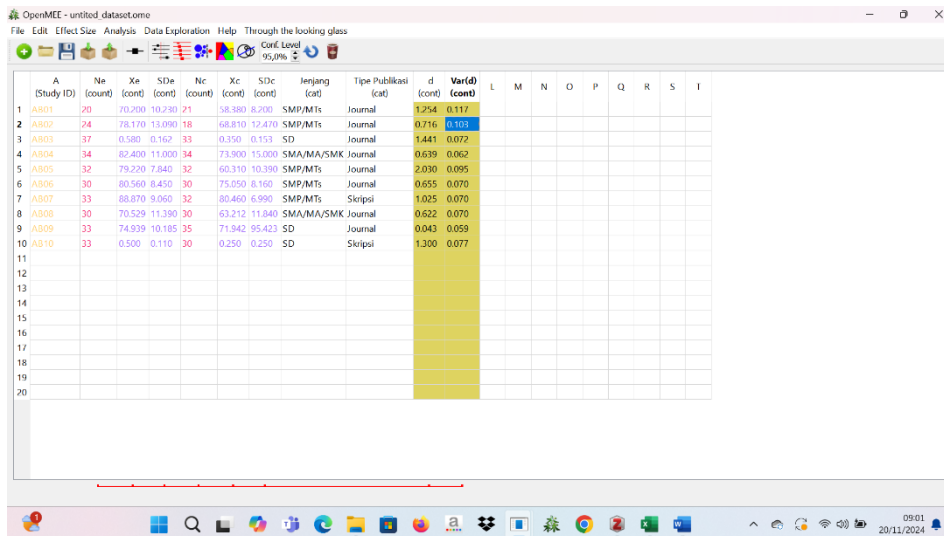

Figure 4. Calculation results of effect size through OpenMEE software

Table 4. Effect Size Calculation Results

No.	Code	*Effect Size*	Category	Variants
1.	AB01	1,254	High	0,117
2.	AB02	0,716	Medium	0,103
3.	AB03	1,441	High	0,072
4.	AB04	0,639	Medium	0,062
5.	AB05	2,030	High	0,095
6.	AB06	0,655	Medium	0,070
7.	AB07	1,025	High	0,070
8.	AB08	0,622	Medium	0,070
9.	AB09	0,043	Very low	0,059
10.	AB10	1,300	High	0,077

The table above shows that the effect size value of each study and with a variety of variations. Namely very low, medium, and high. For the very low category there is 1, namely code AB09. For the medium category there are 4, namely codes AB02, AB04, AB06, and AB08. While for the high category there are 5, namely codes AB01, AB03, AB05, AB07, and AB10.

The next step is to test heterogeneity and determine the estimation model to get the overall effect size. As for the heterogeneity results of the 10 studies in this study, the following results use OpenMEE software.

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Heterogeneity

tau^2   Q(df=9)   Het. p-Value      I^2

0.235   36.762    < 0.001       75.518
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Figure 5: Heterogeneity test

Heterogeneity can be interpreted as the variation of each study used in this research. It can be seen from the figure above that the p-value < 0.001 and I^2 is 75.518, this illustrates that the distribution of data that has been analyzed is above 75%. The data distribution has heterogeneity or high diversity value and is quite good. So that the use of the inquiry learning model has a significant effect on student math learning outcomes.

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Summary
Continuous Random-Effects Model

Metric: Standardized Mean Difference

 Model Results

 Estimate   Lower bound   Upper bound   Std. error   p-Value

 0.957        0.610         1.305          0.177     < 0.001
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Figure 6. Average effect size results based on random effect model

It can be seen that the average effect size value with Hedge's method from 10 studies is 0.957 with a lower limit of 0.610 and an upper limit of 1.305. While the standard error is 0.177 and the p-value is < 0.001. This shows that there is a significant difference between the data from the experimental and control classes. So that the use of the inquiry learning model is effective and has an influence on students' mathematics learning outcomes.
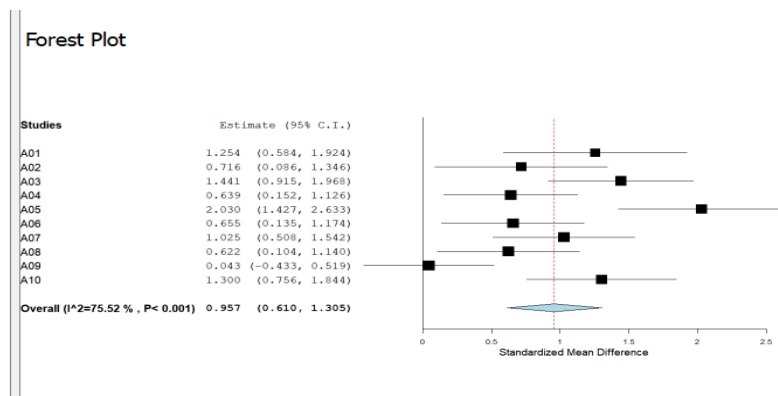

Figure 7. *Forest Plot* by Study Source

It can be seen that the resulting output, the effect size varies from the distribution of data in this study. Seen in the distribution in the graph away from the standard rhombus-shaped plot at the end illustrates the summary effect of the study as a whole. Which is analyzed using effect size data, and a value of 0.957 is obtained, thus it can be interpreted that the effect category is high (Hajiriah *et al.*, 2023).

Table 5. Characteristics Test Results Based on Study

Education Level	N	Effect Size	Lower Limit	Upper Limit	Std. Eror	p-value
SD	3	0,921	0,016	1,826	0,462	0,046
SMP/MTs	5	1,126	0,644	1,608	0,246	< 0,001
SMA/MA/SMK	2	0,631	0,276	0,986	0,181	< 0,001

Based on the information from the table above, it can show that the effect of the inquiry learning model on students' mathematics learning outcomes has an average effect size that varies at each level. At the elementary level has an average effect size of 0.921, at the junior high school / MTs level with a value of 1.126, and at the high school / MA / SMK level has a value of 0.631. Thus, it can be seen that the inquiry learning model has a significant effect on students' mathematics learning outcomes.

CONCLUSION
From the description above, it can be concluded that the results of 10 studies that have been analyzed using OpenMEE software that discuss the inquiry learning model on student mathematics learning outcomes have the largest effect size, namely with a value of 0.957 so that it affects student mathematics learning outcomes. In addition, when viewed from the level of education, the inquiry learning model is effectively applied at the junior high school / MTs level with an average effect size of 1.126, the second most effective is applied at the elementary level with a value of 0.921, and the third most effective if applied at the SMA / MA / SMK level with a value of 0.631.
Based on the description above, teachers can apply the inquiry learning model during the learning process. Because this is very effectively applied at the elementary, junior high school / MTs, and high school / MA / SMK levels. So it is expected to improve student math learning outcomes. In addition, future researchers can add characteristics such as learning materials, learning media, and others.

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