

# Effectiveness of The Inquiry Training Model to Improve Students' Critical Thinking Skills in Learning: Systematic Literature Reviews and Meta-Analysis

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**Abstract:** This study aims to determine the effectiveness of the Inquiry training model to improve students' critical thinking skills in science learning. This type of research is a systematic literature review and meta-analysis. Research data sources come from national and international journals. The process of searching for sources in this study through the Google Scholar database, Eric, ScienceDirect, Wiley, Taylor or Francis, and ProQuest. Data collection techniques with direct observation and documentation. Inclusion criteria in this study are journals or proceedings indexed by SINTA, DOAJ, EBSCO, and Scopus; type of experimental or quasi-experimental research; research variables related to inquiry training in science learning (Biology, physics, and chemistry); journal or proceedings published in 2017-2023 and 5) Has complete research data standard deviation, Standard Error, t value, and others. The data analysis technique is quantitative statistical data analysis with the help of the JSAP application. The results showed an average effect size value of (ES = 1.90) and a Standard Error (SE = 0.67). The results of these findings indicate that the inquiry training model effectively increases students' critical thinking skills in science learning

**Keywords:** Critical Thinking; Inquiry training; Learning Model; Science Learning

## Introduction

Critical thinking is a systematic and logical thinking ability that students must have in the face of globalisation (Ristanto et al., 2022; Elfira et al., 2023; Soffe et al., 2015; Zulkifli et al., 2022). Jamaludin et al., (2022) Critical thinking is a process of thinking deeply in solving a problem. Critical thinking skills help students be more active and creative in learning (Nielsen et al., 2021; Zulyusri et al., 2023; Ichsan et al., 2023; Johnsen et al., 2020). In addition, critical thinking skills encourage students to be more critical in finding a solution to solve a phenomenon or problem (Vaidya, 2017; Eom & Ashill, 2016; Koth et al., 2021). Critical thinking skills are highly effective in developing cognitive skills and recalling

information effectively (Chusni et al., 2022; Yaiche, 2021).

Students' thinking skills in science learning are still low (Ramadhani et al., 2021; Sumarni & Kadarwati, 2020; Suharyat et al., 2023; Fradila et al., 2021). Based on the results of the Program For International Student Assessment (PISA) in 2015, it shows that the level of science literacy of students in science learning obtained a score of 396, ranked 71 out of 78 member countries (Sutiani et al., 2021; Putra et al., 2023; Rahman et al., 2023; Usman et al., 2022; Oktarina et al., 2021). This is supported by the results of the Trends in Mathematics and Science Study (TIMSS) survey, which states that Indonesian students' critical thinking skills score of 397 is far below the average international score of 500

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(Rahmadani et al., 2023). Fauziah et al., (2023) the application of learning models that are not varied, making students less active and focused in learning. Furthermore, the use of evaluation questions that are still focused on aspects of understanding and knowledge so as not to encourage students to think critically (Mursid et al., 2022; Santosa et al., 2023; Suhaimi et al., 2022; Suryono et al., 2023). Furthermore, teachers have not been able to apply learning models that stimulate students to think critically (Ijirana et al., 2022).

The inquiry training model is one of the learning models that can encourage students' critical thinking skills in science learning. The inquiry training model is a learning model that encourages students to develop cognitive abilities and skills in finding answers to students' curiosity (Adnan et al., 2021; Hwang & Chen, 2016; Unal & Yerlikaya, 2021). The inquiry training model helps students be more active and focused in learning activities (Chen et al., 2018; Juanta et al., 2023). In addition, the inquiry training model trains students to obtain information that comes from students' ideas (Sembiring et al., 2023). Research results Mahulae, (2023) stated that the inquiry training learning model in improving students' scientific work skills so as to stimulate students to think critically. So, the inquiry training model provides an opportunity to develop their cognitive potential in learning (Rafiq, 2023).

Previous research by (Kılıç & Sahin, 2022) stated that the inquiry model had a significant effect on concept understanding in learning activities. Research results Nababan (2022) The inquiry training model affects students' conceptual knowledge. Research results Korkman & Metin (2021) The inquiry training model can encourage students' collaboration skills in learning so that students are more active in learning. However, in reality, there are still few studies on inquiry models that describe the effect size of inquiry training models on students' thinking skills in science learning. Based on these problems, this study aims to determine the effectiveness of the Inquiry training model to improve students' critical thinking skills in science learning.

## Method

Research design This study is a type of meta-analysis research. Meta-analysis is a type of research that analyses previous studies by collecting data that can be analysed with statistics (Tsang et al., 2022; Ventura & Conerly et al., 2021; Hawes et al., 2022; Razak et al., 2021). The meta-analysis steps in this study are determining the inclusion criteria; Literature search and data coding; evaluate each study; analyse and interpret the data (Trullàs et al., 2022; Hawes et al., 2022).

## Inclusion Criteria

The inclusion criteria in the meta-analysis in his research are journals or proceedings indexed by SINTA, DOAJ, EBSCO and Scopus; Type of experimental or quasi-experimental research; research variables related to inquiry training in science learning (biology, physics and chemistry); Journals or proceedings published in 2017-2023 and Have complete research data standard deviation, Standard Error, t value, and others.

## Literature Search

The literature search process in this meta-analysis is through the google scholar database, Wiley, Eric, Springer, Hidawi, Plos ONE, and ScienceDirect. The keywords used in this meta-analysis are inquiry training model on students' critical thinking skills in science learning. Determination of data sources must be in accordance with predetermined inclusion criteria. The process of selecting data sources using the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) method can be seen in Figure 1.

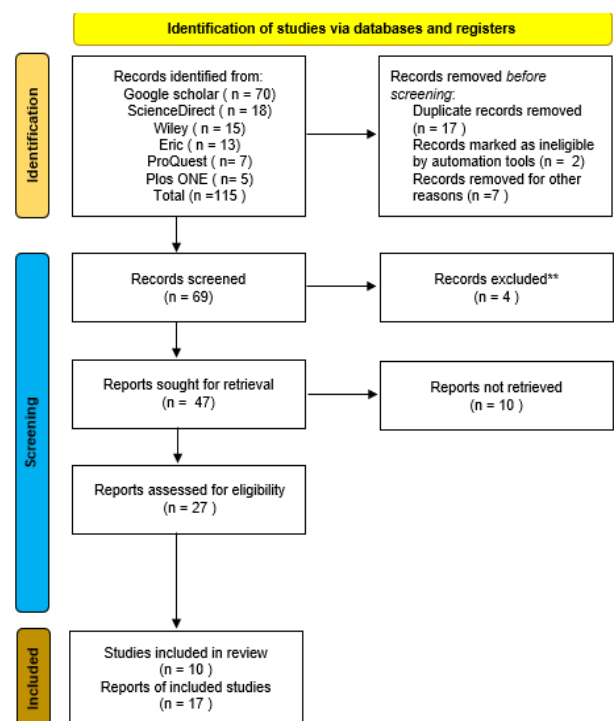


Figure 1. Data Source Selection Method Process through the PRISMA Method

## Statistical Analysis

The analysis in this meta-analysis used the JSAP application to calculate the effect size value of each study, conduct a heterogeneity test and determine the meta-analysis model used; calculate the publication bias value and determine the p-value to test the research hypothesis. The effect size value criteria can be seen in Table 1.

**Table 1.** Effect Size Value Criteria

Effect Size	Criteria
$0.00 \leq ES < 0.20$	Ignored
$0.20 \leq ES < 0.50$	Small
$0.50 \leq ES < 0.80$	Medium
$0.80 \leq ES < 1.30$	High
$1.30 \geq ES$	Very High

Source: (Aisyah & Usdiyana, 2022; Suharyat et al., 2022; Nurtamam et al., 2023)

Furthermore, to calculate publication bias using Rosenthal Fail Safe N (FSN). Research has a resistant publication bias if the FSN /  $(5K + 10)$  value with  $k$  = the number of studies used in the study. The  $p$ -value was used to test the hypothesis in this meta-analysis to determine the effectiveness of the inquiry training model on students' critical thinking skills in science learning.

## Result and Discussion

### Results

From the analysis of 115 national and international journals on the effect of inquiry training models on critical thinking skills in student science learning, only 17 journals met the inclusion criteria. Journals that have met the inclusion criteria are used as data sources in this meta-analysis. Furthermore, the data source of each study was calculated the effect size value, Standard Error and Effect Size Criteria which can be seen in.

**Table 2.** Effect Size and Standard Deviation Value of Each Data Source

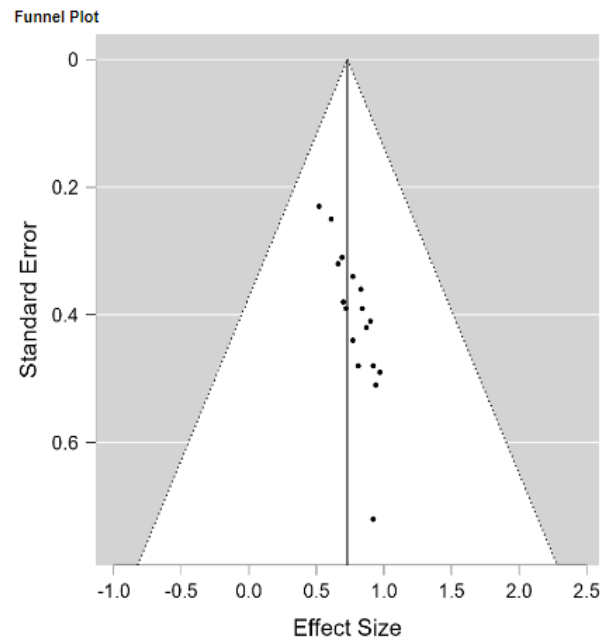
Journal Code	Year	Journal Type	Effect Size	SE	Effect Size Criterion
A1	2021	Internasional	0.52	0.23	High
A2	2017	Internasioal	0.69	0.31	Medium
A3	2021	Internasional	0.84	0.39	Very High
A4	2018	Nasional	0.77	0.34	Medium
A5	2020	Internasional	0.90	0.41	High
A6	2022	Internasioal	0.72	0.39	Medium
A7	2021	Nasional	0.97	0.49	High
A8	2021	Nasional	0.94	0.51	High
A9	2022	Internasional	0.61	0.25	Medium
A10	2023	Internasional	0.92	0.72	High
A11	2018	Nasional	0.83	0.36	High
A12	2019	Nasional	0.70	0.38	Very High
A13	2019	Nasional	0.77	0.44	Medium
A14	2023	Internasional	0.81	0.48	High
A15	2021	Internasional	0.66	0.32	Ignored
A16	2017	Nasional	0.87	0.42	Medium
A17	2021	Internasional	0.92	0.48	Hight
Average effect size			0.782	0.402	Medium

Based on Table 2. Shows that the average value of effect size ( $ES = 0.931$ ) with moderate criteria and Standard Error ( $SE = 0.46$ ). These results conclude that the inquiry training model has a significant effect on critical thinking skills in student science learning. Furthermore, determining the heterogeneity of data sources can be seen in Table 3.

**Table 3.** Heterogeneity Test Results

Model	n	Hedg e's g	95% CI	Q	P	Explanation
Fixed	17	0.743	[0.629; 0.791]	67.539	0.00	Rejec $H_0$
Random	17	0.771	[0.517; 1.590]			

Based on Table 3. The results of the heterogeneity test value ( $Q = 69.432$ ;  $p < 0.05$ ) then the effect size in the study is heterogeneously distributed and the meta-analysis model used is a random effect model. Random effect model is the model used in data analysis. The average effect size value is 0.931. These results explain that the inquiry training model has a positive impact on students' critical thinking skills in science learning rather than conventional learning. Furthermore, determining publication bias using funnel plot which can be seen in Figure 2.



**Figure 2.** Funnel Plot Standard Error

Based on Figure 2. shows that the effect size value is not symmetrical to the vertical line, it is necessary to do the Roshental Fail- Safe N (FSN) test. The results of the Roshental Fail-Safe-N (FSN) test can be seen in Table 4.

**Table 4.** Roshental Fail Safe N (FSN) Test Results

Classic Fail Safe N	
Z-value for observed studies	8.28
The P-value for observed studies	0.00
$\alpha$	0.05
Tails	4.00
Z for alpha	3.21
Number of observed studies	17
Number of missing studies that would bring p-value > $\alpha$	414.00

Based on Table 4. Showing the Roshental Fail Safe N (FSN) test value of 159, then  $414 / (5.17 + 10) = 4.35 > 1$  means that each study in this meta-analysis is resistant to publication bias. Therefore, no studies were deleted and added in this meta-analysis. Next, conduct hypothesis testing to determine the effectiveness of the inquiry training learning model on critical thinking skills in student science learning by using the random effect model hypothesis test.

**Table 5.** Hypothesis Test Results with Random Effect Model

Estimation Model	n	Z	p	Effect Size	SE	95 % CI
Random Effect Model	17	8.218	0.000	0.782	0.177	0.517; 1.590]

Based on Table 5. Shows that the effect size value with random effect size is 0.85. Furthermore, the z value of 8.218 or  $p < 0.05$  means that the application of the inquiry training model is effective for improving students' critical thinking skills in science learning compared to the conventional learning model.

*Discussion*

The application of inquiry training has a significant effect on students' critical thinking skills in science learning. This can be seen from the average effect size value (ES = 0.782) with moderate criteria. Research results (Adnan et al., 2021) The inquiry learning model can encourage students' critical thinking skills and problem solving in science learning. The Inquiry training model helps students be more active and foster interest in thinking in the learning process (Pahrudin et al., 2019; Sutiani et al., 2021). Not only that, the inquiry training model trains students more quickly and easily in understanding the concept of science learning.

The inquiry training model allows students to develop their scientific process in learning science (Simamora, 2014; Sirait, 2012). Research results (Juliani & Ginting, 2014) stated that the inquiry training model can improve learning outcomes and understanding of student concepts in science learning. So, the inquiry training model helps students more easily to think

critically and scientifically in understanding science learning concepts (Sinaga, 2020; Maknun, 2020; Aiman & Hasyda, 2020). Furthermore, the inquiry training model encourages students to focus more easily on thinking in student science learning (Suharyat et al., 2022).

Inquiry learning makes it easier for students to master the subject matter because students find it easier to reason in science learning (Sönmez et al., 2019). In science learning, students are required to think critically and scientifically in the learning process (Rahman & Ristiana, 2020; Suharyat et al., 2023; Fradila et al., 2021; Muskita, 2020). Critical thinking in science learning helps students more easily connect the subject matter with their environment (Supriyadi et al., 2023; Smith et al., 2019; Kılıç & Sahin 2022). Not only that, models in science learning can help the process of student cooperation in learning (Asmoro, 2021). So, the application of the inquiry training model in teaching helps teachers more easily encourage students to think more easily (Gültepe & Kılıç, 2021).

**Conclusion**

From this study it can be concluded that the average effect size value is (ES = 1.90) and Standard Error (SE = 0.67). These findings indicate that the inquiry training model effectively increases students' critical thinking skills in science learning. The inquiry training model encourages students to think critically so that students are more active and focused in science learning activities.

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**Author Contributions**

Wiwid Suryono and Linda Winiarsi contributed to collecting and selecting research data, Tomi Apra Santosa contributed to analyzing and statistical testing of data. Baso Intang Sappaile and Moh. Solehuddin contributed to the analysis of research results.

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**Conflicts of Interest**

The authors declare no conflict of interest.

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