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Meta-analysis Influence of Integrated Mind Mapping Inquiry Based Learning Model on Student Problem Solving Skills

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Abstract: A This study aims to determine the effect of inquiry-based learning model integrated mind mapping on students' problem-solving skills. This type of research is quantitative research with meta-analysis methods. Data comes from international journals or proceedings published 2015-2023. Data search through ScienceDirect, Springer, ProQuest, ERIC and Taylor of Francis databases. Research should be selected for data in meta-analyses. The inclusion criteria are that research must be experimental methods or quasi-experiments, research indexed by Scopus, Sinta, Web of Science, Microsoft Academic and EBSCO, Research has an experimental class inquiry learning model integrated mind mapping and conventional model control class, research has a number of samples (N), correlation values (r), t, and F and a sample consisting of 1021 participants. Data analysis with the help of JASP to determine the value of effect size, heterogeneity test and publication bias. The results showed a positive influence of minde mapping-based inquiry learning model on students' problem solving skills ($z = 7.019$; $p < 0.001$; 95% CI [0.61; 1.26]. This finding shows that the influence of mind mapping-based inquiry learning models is included in the very high category (rRE = 1.31).

Keywords: Inquiry Learning; Meta-analysis; Mind Mapping; Problem Solving

Introduction

The industrial revolution 4.0 provides enormous changes in the world of education. Education today leads teachers to improve students' ability to have problem-solving skills (Irham et al., 2022; Putri et al., 2022). Problem-solving thinking skills play an important role in encouraging students to solve problems in life (Kembara et al., 2019). In addition, students who have problem-solving skills are more active and creative in learning (Sari et al., 2021; Supena et al., 2021; Işiklar & Öztürk, 2022). According to Kök & Duman (2023), problem-solving skills train students to provide the right solutions in making a decision. Furthermore, problem-solving skills can encourage students to have higher-order thinking skills in learning (Amalina, 2023).

In fact, students' problem-solving skills in the learning process are still relatively low (Susanti et al., 2023; Ramadan et al., 2019; Hariyanto et al., 2023). Low problem-solving skills are caused by teachers not providing opportunities for students to be active in learning (Sudarsono et al., 2022), and students have not been able to provide ideas or solutions in solving problems in learning (Mulyanto et al., 2018; Hidayati & Wagiran 2020). In addition, in learning activities students still have difficulty in solving problems related to problem solving (Yusri et al., 2018; Simanjuntak et al., 2021) and the selection of learning models carried out by teachers is not right to improve students' problem-solving skills. Not only that, the results of TIMSS in 2015 stated that students' problem-solving abilities were relatively low, only obtaining a score of 397, ranked 64th in the world out of 68 countries (Sumiantari et al., 2019; Nurtamam et al., 2023; Utomo et al., 2023; Suryono et al., 2023). To overcome these problems, there needs to be a model that can encourage students' problem-solving skills.

The inquiry-based learning model is a learning model that encourages students to be more active in

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finding concepts and principles in learning activities (Sreejun & Chatwattana, 2023; Astalini et al., 2023; Antonio et al., 2022). The inquiry learning model trains students to develop high curiosity skills in learning (Machado & Nahar, 2023). Kılıç & Sahin (2022) inquiry based learning model students can learn independently to find the concepts and material learned. Furthermore, the inquiry learning model encourages students to actively learn to formulate mistakes, analyze and make decisions (Sutarningsih, 2022). Not only that, inquiry model learning is able to develop students' scientific potential and attitudes (Adnan et al., 2021; Andrini, 2016). Inquiry learning can be integrated with mind mapping.

Mind mapping is a lesson that trains students to present information in the form of concepts and ideas in the form of pictures so that students more easily remember information (Zhao, 2016; Jones et al., 2012). Learning with mind mapping can develop students' interest and motivation to learn (Fauzi & Fikri, 2018). In addition, learning mind mapping can improve students' understanding of concepts (Muhlisin, 2019). Shi et al., (2022) said that mind mapping learning has a positive influence on student learning outcomes.

Research by Turnip et al. (2016); Rizki Ramadhani et al. (2021); Yuliati, 2018) said that the inquiry learning model has a significant influence on students' problem-solving abilities. Meanwhile, research by Anggreini (2019); Meiarti & Yulianti (2020) said that problem-solving skills are not always better using an integrated inquiry model, mind mapping, than conventional models. Therefore, the same study provides different results can cause a contradiction so that conclusions can be subjective (Susanti et al., 2020; Tamur et al., 2020). Therefore, to draw an accurate and in-depth conclusion, it is necessary to conduct a meta-analysis (Aybirdi, 2023).

Furthermore, several meta-analysis studies before dealing with the influence of inquiry-based learning models on mind mapping integration still found many weaknesses. There are meta-analysis studies that have not analyzed publication bias, thus influencing the true effect (Lazonder & Harmsen, 2016; Praminingsih et al., 2022). Furthermore, previous meta-analysis studies have not looked at sample characteristics so that it will affect data heterogeneity (Firman, 2019). Therefore, this study aims to determine the effect of the mind mapping-integrated inquiry learning model on students' problem-solving skills.

Method

Design Research

In this study using a type of meta-analysis research. Meta-analysis is a type of research that examines and analyzes previous research to obtain a more accurate and in-depth conclusion with quantitative analysis (Baysal et al., 2023; Öztürk et al., 2022; Ichsan et al., 2023; Zulkifli et al., 2022). This meta-analysis aims to determine the effect of mind mapping-based inquiry learning models on problem-solving skills. According to Borenstein et a., (2009) the meta-analysis procedure consists of determining inclusion criteria, collecting and coding data, and analyzing data with statistics.

Data Collection

Meta-analyses of data entered came from Google Scholar, ERIC, ProQuest, Wiley and Taylor of Francis. The key to data search is "model inquiry", the influence of inquiry models on problem solving skills", the influence of mind mapping-based inquiry learning models on problem solving. Furthermore, in this data collection obtained 612 national and international journals. Data selection using the PRISMA 2020 method. Thus, 17 journals that meet the inclusion criteria can be seen on.

Table 1. Inclusion and Exlusion Criteria

Inclusion	Exclusion
Publication in 2018-2023.	Research in the form of a thesis or dissertation.
Publications come from journals or proceedings indexed by Scopus, WOS, EBSCO, Microsft Academic and Sinta.	Research that describes incomplete data.
Research should be experimental methods or quasi-experiments with mind mapping-based inquiry models and conventional learning control classes.	
Provide complete data in the form of mean, sample size (N), Standard deviation (SD), F, t, r values to calculate effect size.	
Articles are published in Indonesian and Englis and open access.	

Inclusion and Exlusion Criteria

To obtain valid data in the meta-analysis, it is necessary to establish inclusion and inclusion criteria. The inclusion and inclusion criteria in this meta-analysis can be seen in Table 1.

Data Coding

Data coding in meta-analysis research is very important to make it easier for researchers to analyze data (Romadiah et al., 2022; Malički et al., 2021). Data coding in the meta-analysis describes research characteristics consisting of study code, year of publication, country, sample size, F, r, and t values and journal indexation. The results of data coding can be seen in Table 2.

Table 2. Data Coding 17 journals

Study Code	Year	Sample	N	r	t	F	Index
AT1	2018	SMA	60		0.812		Sinta
AT2	2017	SMA	84		0.967		Sinta
AT3	2020	JUNIOR	125		0.613	4.082	Ebsco
AT4	2020	SMA	100		0.842		Scopus
AT5	2023	SMA	93		0.590		Scopus
AT6	2021	SD	86		0.925		WOS
AT7	2019	SD	48		0.714		Sinta
AT8	2018	JUNIOR	38		0.821		Sinta
AT9	2021	SMA	60	0.417			Scopus
AT10	2022	SMA	54		0.472		Scopus
AT11	2018	JUNIOR	220		0.816	5.410	Sinta
AT12	2020	SMA	128		2.155		Sinta
AT13	2023	SMA	80	0.582			Scopus
AT14	2023	JUNIOR	96	0.498			Ebsco
AT15	2023	SMA	30		0.454		Scopus
AT16	2022	JUNIOR	46		1.054		Sinta
AT17	2021	SD	72		0.788		Scopus

Data Analysis

Data analysis in this study was carried out through steps consisting of 1) analyzing the characteristics of the research sample; 2) data encoding; 3) convert t and f values into r values; 4) test the value of data heterogeneity; 5) calculate the summary effect or mean effect size; 6) analysis of forest plots and funnel plots; 7) hypothesis testing and 8) research publication bias checking (Chamdani et al., 2022). Analyze the data in this meta-analysis with the help of JASP software. Furthermore, the criteria for the value of effect size meta-analysis guided by the criteria (Cohen et al., 2007) can be seen in Table 3.

Table 3. Cohen's Effect Size

Effect Size Value	Category
$0.00 \leq ES \leq 0.20$	Low
$0.20 \leq ES \leq 0.80$	Medium
$ES \geq 0.80$	High

Result and Discussion

Result

Based on the search results through the Google Scholar database, ERIC, ProQuest, Wiley and Taylor of Francis obtained 612 journals but only 17 journals met the inclusion criteria that had been set. Furthermore, the 17 journals obtained various r, t and f values from each study. To test the heterogeneity of publications first to convert t or F values that do not yet have r values into r values. The results of the publication heterogeneity test can be seen in Tables 4 and 5.

Table 4. Publication Heterogeneity test results

Parameters	Q	Df	p
Omnibus Test of Model Coefficients	76.108	1	< 0.001
Test of Residual Heterogeneity	248.572	16	< 0.001

Note. p-values are approximate.
Note. The model was estimated using the Restricted ML method

Table 5. Residual Heterogeity Test

Parameters	Value
τ^2	0.187
τ	0.496
I^2 (%)	95.0112
H^2	12.914

The result of heterogeneity obtained a value of Q = 248.572 with a p value of < 0.001; τ or $\tau^2 > 0$; I^2 (%) is close to 100 %., so the 17 effect sizes analyzed are heterogeneously distributed. Next, calculate the value of summary effect size or mean effect size from 17 publications analyzed and publication bias using a random effect model. The results of the summary effect size or mean effect size can be seen in Table 6.

Table 6. Summary Effect Size/mean effect size value

Parameters	Estimate	Standard Error	z	p	95% Confidence interval	
Intercept	0.943	0.317	8.252	< 0.001	0.587	1.361

Table 6, the results of analysis with random effect model explain the significant influence of inquiry-based learning model based on mind mapping on students' problem-solving skills (z = 8.252; 95% Confindece interval [0.587; 1.361] and a p-value of 0.001. This finding concludes that there is a significant influence of mind mapping-based inqyiry-based learning models with problem-solving skills with high influence categories (r_{RE} = 1.16). The next step is to conduct an analysis through a forest plot that aims to determine the summary effect size through points at certain intervals to make a comparison in more detail and clearly. The results of the analysis of 17 journals through foresplot can be seen in Figure 2.

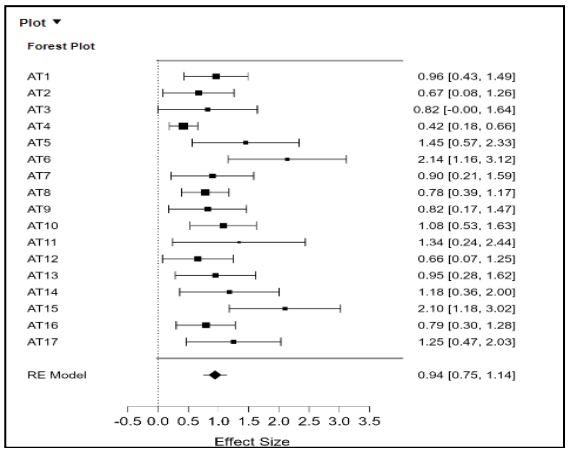

Figure 1. Forest Plot

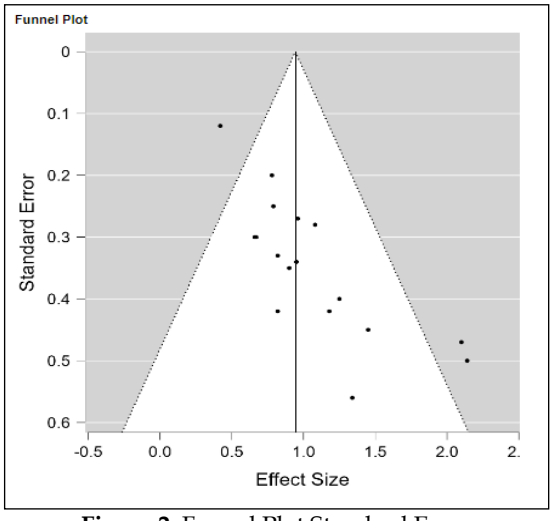

Figure 2. Funnel Plot Standard Error

Based on analysis through forest plot, the effect size value ranges from 0.42 to 2.14. Next, check publication bias with funnel plots to see if there may be publication bias in symmetric or asymmetric research samples. The results of the publication bias analysis with funnel plots can be seen in Figure 3. Based on the analysis of publication bias, it does not explain in detail the bias of publications that clash symmetrically or asymmetrically. Therefore, there is a need for Egger's test. Egger's test results can be seen in Table 7.

Table 7. Regression test for funnel plot asymmetry (Egger's test)

Parameters	z	p
Sei	0.482	2.15

Based on Table 7, the value of Z = 0.482 > 0.05. This finding concludes that the effect size on the funnel plot is symmetrical. Therefore, in the meta-analysis there was no publication bias against the 17 journals analyzed.

Discussion

Based on the analysis of 17 journals that have met the inclusion criteria, it shows a significant influence on the application of the mind mapping-based inquiry-based learning model on students' problem-solving skills (p < 0.05). The mind mapping-based inquiry based learning model helps foster students' interest and motivation and confidence in discovering the concepts or theories learned by themselves so as to encourage students to have problem-solving skills (Fielding-Wells et al., 2017; Khasawneh et al., 2023; Meulenbroeks et al., 2023).

Furthermore, from the effect size analysis 17 explained that the inquiry-based learning model based on mind mapping had a positive effect in the high category on students' problem-solving skills (r_{RE} = 0.943). The inquiry-based learning model encourages students to learn independently and think scientifically so that students are able to make a decision (Sreejun & Chatwattana, 2023; Rubio & Conesa, 2022). Inquiry-based learning model based on mind mapping, students learn more creatively in mapping a subject matter learned. Problem-solving skills play an important role for students in providing ideas or ideas in solving a problem (Özpinar & Arslan, 2023; Widodo et al., 2023).

Problem-solving skills train students in formulating, analyzing and drawing conclusions in solving a problem (Treepob et al., 2023; Mahanal et al., 2022). In addition, problem-solving skills become a basic skill that students must have in dealing with problem solving in life (Ron, 2022; Özeren et al., 2023;

Afacan & Kaya, 2022). Problem solving is very important to train students to develop higher-order thinking skills in learning. Not only that, problem-solving skills affect students' cognitive, affective and psychomotor abilities. This is supported by several studies including (Anderson et al., 2015; Griffin et al., 2023; Sappaile & Djam, 2020). Therefore, students who have problem-solving skills can think logically and deeply in learning.

Furthermore, the mind mapping-based inquiry-based learning model contributes to teachers in improving students' skills in schools (Rafoth & Foriska, 2016; Antonio et al., 2022). Furthermore, problem solving skills train students in providing new and innovative knowledge in learning activities. Therefore, the existence of an inquiry-based learning model based on mind mapping can hone students' ability to remember information longer (Abdi, 2014; Pedaste et al., 2015; Levy & Petrulis, 2012). Learning through mind mapping students in making material notes that suit their interests so that students have higher thinking skills.

Conclusion

From the meta-analysis research, it can be concluded that there is a positive influence of minde mapping-based inquiry learning models on problem solving skills s = students ($z = 8.252$; $p < 0.001$; 95% CI [0.587;1.361]. This finding shows that the influence of mind mapping-based inquiry learning models is included in the very high category (rRE = 0.943). Inquiry-based learning model based on mind mapping students learn more independently and creatively to find a theory and learning principles that have been runnered. The mind mind mapping-based inquiry learning model makes a major contribution to teachers in developing students' thinking skills in learning.

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Conflicts of Interest
The authors declare no conflict of interest.

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