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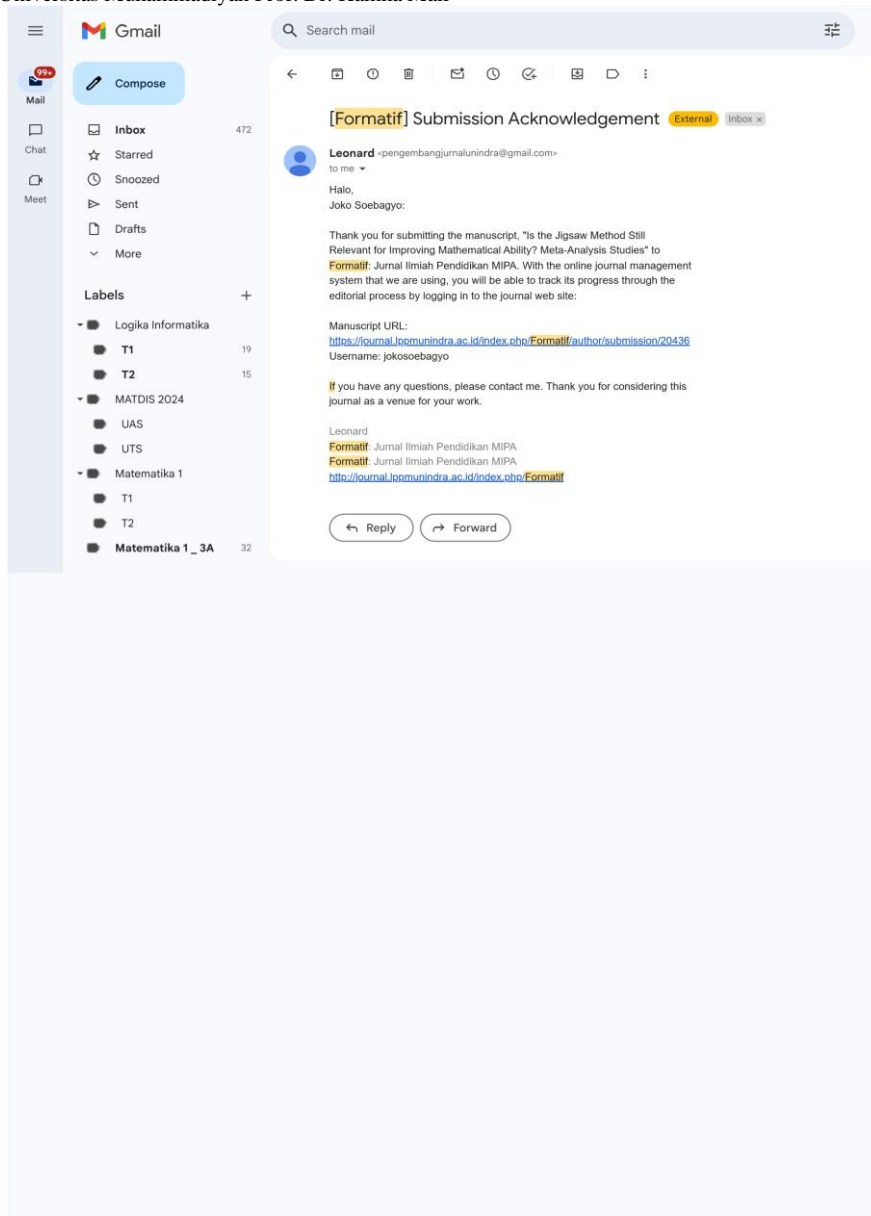
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# Is the Jigsaw Method Still Relevant for Improving Mathematical Ability? Meta-Analysis Studies

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## Abstract

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Based on the findings of research that has been done, learning the Jigsaw method also has an influence on the mathematical ability of students but some do not have a significant influence. As a result, meta-analysis research is required to provide thorough and in-depth conclusions about the Jigsaw method's applicability to students' mathematical abilities. Comprehensive Meta-Analysis is used to evaluate property values based on comparisons with similar properties in the same area. Data obtained from Publish or Perish with a year level from 2010 to 2023 there are a total of 501 articles with a Google Scholar data base. The total number of eligible journals and will be analyzed is 30 samples with a total of 1252 subjects. The moderator variables in this study consider the country, education level, sample size and publication source. According to the study's findings, the Jigsaw technique had a significant impact on arithmetic ability (P-value 0.05), with an effect size of 1.146 classed as extremely high based on a fixed effect and an error standard of 0.045. The results showed that the Jigsaw method is still relevant to improve students' mathematical skills, especially at the elementary school level. In contrast, The meta-analysis revealed that the Jigsaw method had no effect on pupils' mathematical abilities across country categories.

**Keywords:** Jigsaw methods, mathematical abilities, meta-analysis

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## INTRODUCTION

Recognize mathematics as an abstract science that is the basis for achieving other sciences. Mathematics complements all existing sciences ranging from science, technology, art and many others (Kamarullah, 2017). The level of difficulty in mathematics is often used as a benchmark in achieving success. No wonder many of the nation's students are required to be proficient in mathematics. Sometimes the difficulty in solving abstract problems often makes interest in learning decrease so that you are lazy to learn, this is a trigger factor for problems in learning (Siswono, 2014). In mathematics, mathematical ability is not only measured on one ability. Mathematical abilities are grouped into five understandings ranging from mathematical understanding, problem solving, reasoning, connection and communication (Sumarmo, 2012). Mathematics learning must instill rational thinking processes with the laws of mathematical logic to develop thinking processes in solving mathematical problems (Maarif et al., 2018). In understanding logic, of course, requires motivation and good learning and teaching. Not all teaching provided is able to make some students interested in learning. Therefore, as a good teacher, there needs to be variety in providing learning models. This variant is used to ensure the learners grasp the topic and that objectives for learning are achieved. Currently, there are many learning models that are often found, ranging from Problem Based Learning (PBL), Project Based Learning (PJBL), Realistic Mathematics Education (RME), to Cooperative Learning (CL). The development of technology, a lot of research related to learning. In fact, not a few studies that vary learning with other methods.

Cooperative learning was first studied in 1898 by Roger and Johnson in about 600 experiments. Cooperative learning is learning that creates interaction between group members and

teachers try to condition it by motivating students to always develop a sense of mutual need in a team (Jaelani, 2015). Social behavior learning is specifically developed to assist students in collaborating while learning. Cooperative learning is a learning paradigm in which students participate and interact with one another in small groups of four to six persons (Saputra et al., 2017). There are various variations of models that can be used in cooperative learning, namely (1) STAD, (2) Group Investigation, (3) Jigsaw, (4) Think-Pair-Share, (5) Inside-Outside Circle, (6) Make a Match, (7) Listening Team, (8) The Power of Two, and (9) Bamboo Dancing.

Jigsaw is one of the models of cooperative learning. Jigsaw type learning is learning in a learning group where there is interaction between each group member and has responsibility for the material in the group and the ability to master and teach the topic to the other members of the group (Lubis & Harahap, 2016). The initial group and the expert group are displayed in the puzzle cooperative learning paradigm. The origin group, or parent group of students, consists of students from different racial, ethnic, and socioeconomic backgrounds. While the expert group consists of members of different origin groups and is tasked with researching and studying certain subjects while carrying out tasks that will be communicated to members of the origin group. A number of specialists from the initial group have been combined to form the expert group. Being interconnected with each other where each student is able to convey the information needed to their teammates so that the goal in solving problems can be achieved is the key to the success of Jigsaw (Werdiningsih & Mukhlisin, 2021). In this learning students work in a team and are assigned to read and study a subject. Random selection is made for each member of the group who is designated as an expert in a particular field. Furthermore, the experts reported to the group and met with other groups to discuss the material learned then returned to their group to teach the material to their teammates (Widyastuti, 2015). The characteristic of the Jigsaw type that distinguishes it from other types of cooperatives is that there are study groups and specialist groups (Hibattulloh & Sofyan, 2014).

One of the learning models that can promote student activity, involvement, and knowledge of the material is cooperative learning. The Jigsaw cooperative learning model is one example (Nurfitriyanti, 2017). This learning model is possible to be applied to young children, because this type of children is also divided into several heterogeneous groups according to ability and gender, so that group characters are formed into parallels (Poerwati et al., 2020). The Jigsaw cooperative paradigm is intended to improve students' problem-solving and critical thinking abilities because in discussion activities students are grouped into specialist groups and origin teams to solve mathematical problems (Handayani, 2020).

In understanding abstract science, the ability to train critical thinking needs to be taught to students (Sarman & Soebagyo, 2022). Critical thinking is the ability of human thinking that has systematic and logical steps (Saviraningrum & Soebagyo, 2022). Thinking logically means being precise, which is an important skill for life and work to work effectively in all areas of life. The advantage in critical thinking, we can assess the level of thoroughness or truth of the question and without any information it is not easy to express what we want to convey (Zuharni, 2022). In addition, mathematical creative thinking skills, namely the ability to think based on data and information, are available to find possible answers to such problems from different points of view on problems in each individual where it is more emphasized the suitability of answers and the versatility of answers (Yayuk et al., 2020). That is, creative thinking skills should belong to everyone (Florentina & Leonard, 2017). No less important, to find relationships from a representation of concepts and procedures, to grasp between mathematical themes and apply mathematical concepts in other fields or daily life, the capacity to make mathematical connections is required (Widarti, 2013).

The Jigsaw method of learning, which is derived from research findings, assists students in understanding the findings they make (Sari & Fitriani, 2018). In other studies there is an influence on the mathematical ability of students but there are also those that do not have a significant influence. Of course, in various studies there are different kinds of conclusions even though the variables studied have similarities. Based on the existing problems, Meta-analysts can provide comprehensive and in-depth conclusions on certain variables or topics that want to be discussed. This study can answer how much influence the Jigsaw method has based on the desired category variables. One of the results of this study is a significant improvement in students' mathematical abilities after attending the Jigsaw method lecture with discussion assessment and based only on the findings of the preliminary and final tests (Edriati et al., 2015).

## METHODS

This study focuses on quantitative data research analysis based on Google Scholar database sources, specifically to investigate *Jigsaw models* with *math ability*. The purpose of this analysis was to identify the magnitude of the influence on the Jigsaw learning method and to investigate the impact of characteristics on mathematical ability in determining the variation in effect size of each available research. Analysis using a meta-analysis approach is used to achieve this purpose. Meta-analysis is used to compare primary study with other scientific advancements in the form of drawing statistical findings in the form of effect size on quantitative data studies based on relevant themes (Rosdiana, 2021). The steps in compiling the meta-analysis, starting from; (1) choose the criteria for the article to be researched, (2) look for literature sources related to relevant research to be used, (3) code the article to be used, (4) conduct analysis and classification, (5) interpret findings based on the article under study (Sukmawati, 2020).

### Literary Search

This research uses the Google Scholar database as a location for document search. Furthermore, the use of Publish or Perish is applied as a reference in downloading studies related to the application of the Jigsaw method by combining keywords into Jigsaw, math ability (Eryanti & Soebagyo, 2021; Haniyah & Soebagyo, 2021; Sarman & Soebagyo, 2022). Seen in Figure 1, it is obtained that the search process for the application of the Jigsaw method on Google Scholar using the PoP application reaches 500 data.

Cites	Per year	Rank	Authors	Title	Year	Publication	Publisher	Type
9	3.00	1	N Rambe, E Syah...	The Effect of the Jigsaw Cooperat...	2020	... Research and Critics in ...	pdfs.semanticscholar.org	PDF
41	5.86	2	I Dewa, M Haryap...	... of Geometri Teaching Materials...	2016	Journal of Education and ...	ERIC	
14	2.80	3	S Samson, D Darh...	The students' mathematical conc...	2016	Journal of Physics ...	scipublishing.org	PDF
34	6.80	4	DP Sari, E Syahp...	An analysis of spatial ability and ...	2018	American ...	article.scribd.com	
22	2.75	5	S Edriat, Y Angga...	Ethnoliter Model Jigsaw Disant...	2015	Jurnal Cakrawala Pendidikan...	jurnal.unp.ac.id	
4	1.55	6	Adi Hana, D Dwi...	Mathematical creative thinking a...	2020	Unnes Journal of Mathem...	journal.unnes.ac.id	
25	6.25	7	E Erika, K Kartun...	Understanding Ability of Mathem...	2019	Journal of Primary Educat...	journal.unnes.ac.id	
2	0.67	8	IS Yudianto, A Nu...	The Effect of Jigsaw Cooperative ...	2020	Formatif: Jurnal Ilmiah ...	journal.fgmmunindia.ac.id	
6	4.00	9	H Saadiah, T Syaf...	Student team achievement divisi...	2021	Depdiknas: Jurnal ...	ejournal.steridiana.ac.id	
46	5.75	10	F Maerdy, A Rey...	The discrepancy of students' mat...	2015	International Journal of ...	ijer.com	PDF
1	0.20	11	DR Siti, E Surya...	Differences Ability of Problem Sol...	2018	3rd Annual International ...	afitadri-gress.com	
19	2.11	12	K Adu, M Wihara...	Journal Statistik Matematika	2014	Jurnal Statistik Matematika	jurnal.unp.ac.id	
21	2.33	13	C Young, E Cartm...	Gestures and speech input are inte...	2014	Proceedings of the ...	scholarship.org	PDF
60	3.45	14	C Darnen, C Buch...	The jigsaw technique and self eff...	2012	European journal of prop...	Springer	
44	11.60	15	R Faras, C Molem...	Visual and spatial working mem...	2017	Frontiers in Psychology	frontiersin.org	HTML
14	2.33	16	M Juliana, E Surya	An Analysis Of Jigsaw Cooperative...	2017	... Of Advance Research...	researchgate.net	PDF
4	0.80	17	AA Sitopai, H Ma...	THE DIFFERENCE OF STUDENTS...	2018	... Journal of Mathematic...	com.ac.uk	PDF
5	1.00	18	AA Sitopai, H Ma...	... OF STUDENTS ACHIEVEMENT L...	2018	Infinity Journal	injournal.ubbjember.ac...	

Figure 1. Google Scholar database search results (Jigsaw, Math ability)

### Literary Inclusion Criteria

Throughout the present investigation, the research that was successfully found using the PoP software was then collated based on the requirements listed following: (1) write keywords using English settings, then retrieve the Google Scholar database at a vulnerable time between 2010-2023, (2) statistical information is used to obtain the effect size value. And journals or study criteria that do not match will be removed from the analysis data, and (3) learning to use a quantitative approach where in quantitative data there must be control groups and experiments. Journals or papers with just a single sample and a qualitative approach will be excluded from the data analysis.

The data screening in this investigation was done using the PRISMA protocols shown in Figure 2.

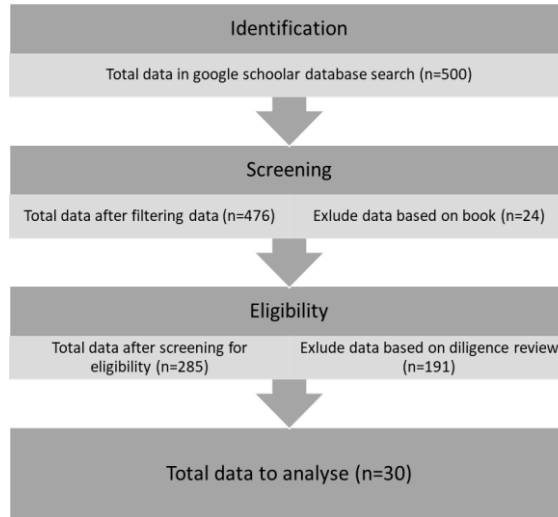


Figure 2. Filter data using PRISMA

### Coding

All studies that match the criteria are coded manually using a detailed coding scheme based on protocols. In this study, the instrument was carried out using the provision of codes (*categories*). Coding is done to separate individual data information into numerical data. A random sample of 5 valid studies was reproduced and divided among coders to determine reliability. The coder is given a copy of the article, as well as the coding form and protocol. To assess the reliability of these coders, the following formula is employed to calculate percent agreement (PA):

$$PA = \frac{N_A}{N_A + N_P} \times 100\%$$

In this scenario,  $N_A$  represents the total number of agreements, while  $N_P$  represents the entire number of disagreements.

### Statistical Analysis

The data was evaluated with the CMA application, with special attention paid to the effect size, which is defined as the influence of the Jigsaw approach on students' mathematical skills. The Comprehensive Meta-Analysis is beneficial for adjusting the effect size of research, including the overall effect size, P-value, Q-statistic, and truth interval. In addition, the program creates research forest plots and funnel plots. The g Hedges measure was utilized in this analysis, and the size effect was classified as less than 0.2 (negligible), 0.2 to 0.5 (small effect), 0.5 to 0.8 (moderate effect), 0.8 to 1.3 (big effect), and more than 1.3 (very large effect) (Cohen et al., 2007). The random effect technique was chosen as the estimation method since there is no assumption that all research have the same effect. The randomized effect model in this study was selected after a successful heterogeneity test. The p value is used to perform this test. If the p-value is less than 0.05, all studies will be identical, and the null hypothesis and homogeneity will be rejected. The rejection of the null hypothesis suggests that population parameters may not be measured with the same effect size across studies or study groups (Retnawati et al., 2018). There is evidence that different study categories have different effects on study effect sizes.

To avoid misrepresentation of results, publication bias is checked. Publication bias is the likelihood that studies appearing in published literature are considered statistically significant to be published (Cooper et al., 2009). In anticipation, a bias analysis was carried out on the funnel plot to see if the research was free from bias. When the distribution of impact sizes on vertical lines was symmetrical, publication bias was judged strong in this study. However, if the size distribution of the effect is not perfectly symmetrical, it is necessary to use the trim and fill method. If the observed

effects and virtual effects generated by randomized effects models are found to be similar, then the study is immune to publication bias.

## **RESULTS & DISCUSSION**

### ***Results***

#### **Literature Search Results**

The goal of this study was to determine whether the magnitude of the effect created had an effect on learning the Jigsaw method and mathematical competence based on category variables. Therefore, researchers try to search literature using PoP (Publish or Perish) software by applying several criteria. The first criterion, researchers use vulnerable research time in 2010 – 2023. Furthermore, the second criterion of researchers used the keywords Jigsaw and Math ability, and the maximum number of results was limited to 500 data. From the topics used, 501 articles were collected, with 24 data coming from books and the rest coming from journals, citations and documents.

#### **Literature Selection Results**

After setting criteria for literature search, the researcher converts the data into excel and eliminates the data in the appropriate journal. First, researchers filter data that is included in journals or articles. Second, researchers use a quantitative approach to collect data that has an experimental class and a control class. Third, researchers collect statistical data such as the number of samples, average values and standard deviations. This statistical data aims to calculate the size of the effect to be studied. Furthermore, screening through the PRISMA method is carried out to ensure the accuracy of the data obtained. Not only that, but researchers must guarantee that the journal's title and theme are consistent with the criteria variables.

#### **Results Criteria**

The results of the criteria in this study focused on vulnerable years 2010 - 2023. The selection of criteria on this year's vulnerability was carried out to ensure that the available research is up-to-date. From the results of the criteria that have been filtered, researchers consider choosing research sourced from journals and proceedings. In addition, researchers also obtained various journals from various countries with the same topic, ranging from Asian to European countries. Furthermore, researchers consider the degree of education beginning with (pre-school, elementary, junior high, high school, and university). The many variations that have been studied at this level of education add to the accuracy of a study. Furthermore, researchers also looked at the number of sample sizes in a study and paid attention to whether each of these journals had a control class and an experimental class. The selected research is also equipped with post-test and pre-test data, average values and standard deviations to see the extent of the data spread and whether there are data deviations in the average value.

#### **Statistical Analysis Results**

The results of the study here aim to answer the research question. Figure 3 depicts the findings of a meta-analysis of 30 filtered and collected data from Google Scholar. Figure 3 contains the identification of the names of the studies. Furthermore, the magnitude of the effect is shown which contains the results of the intervention. It can be seen that there is 1 data that is less than 0 or under consideration, while the average confidence interval that stretches horizontally or is more than 0 is on the right. This means that the effects of the intervention are beneficial. In addition, figure 3 also shows the heterogeneity of a data to see discrepancies in the source of findings from the study.



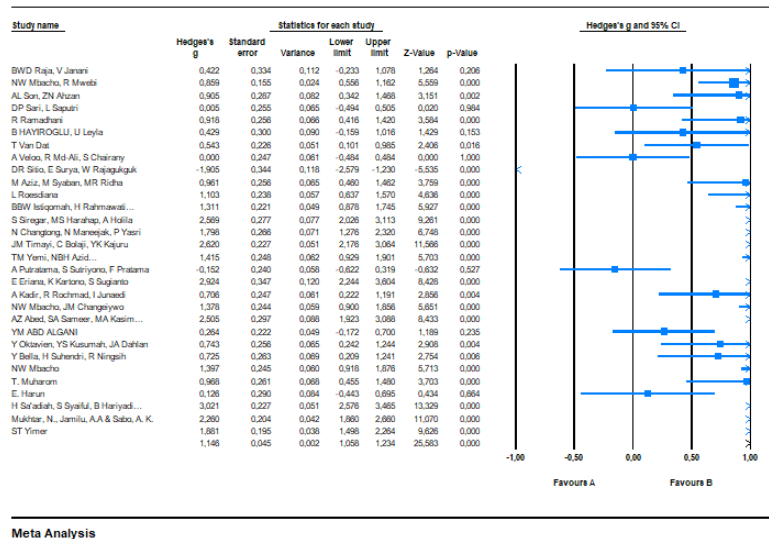


Figure 3. Research Forest Plot

According to Figure 3, there is an inconsistent response rate. It is clear that the research is likely to be diverse. As a result, it must be statistically examined such that the starting assumptions are consistent with the estimation approach.

Table 1. Meta Results - Analysis according to the Estimation method

Model	N	Hedge's	andard er	Test of null		Q	P	Decision
				Z-value	P-value			
Fixed-effects	30	1.146	0.045	25.583	0.000	447.062	0.000	Reject
Random-effects	30	1.095	0.177	6.189	0.000			

Table 1 displays the findings of a meta-analysis of 30 papers from conferences and international journals. Table 1 shows that the P value is 0.05, indicating that each study has a diverse impact size. Therefore, a fixed effect model with a very high effect size of 1,146 was used. Using a null test obtained P less than 0.05 with a fixed effects model. In addition, a z value of 25,583 was obtained indicating that the research results were significant for  $P < 0.05$  (Musna et al., 2021). To put it another way, the Jigsaw-type learning model has a big impact on mathematical ability.

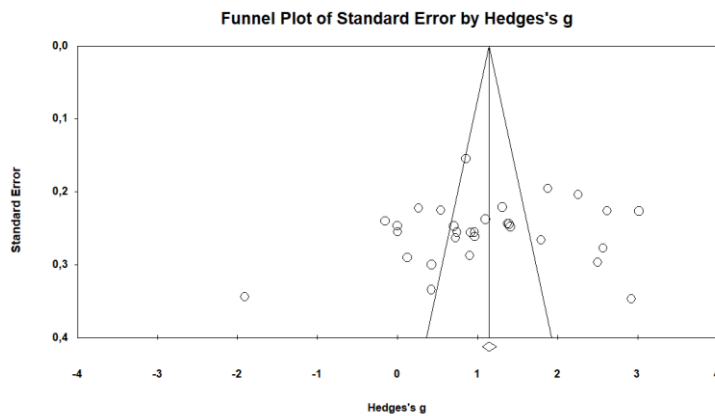


Figure 4. Funnel plot of 30 samples

Then, as shown in Figure 5, we will show a funnel plot with the research spread out and not symmetrical in the funnel, requiring trim and fill to check whether there is a difference with the influence of publication bias.

#### Duval and Tweedie's trim and fill

		Fixed Effects			Random Effects			Q Value
	Studies Trimmed	Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit	
Observed values		1,14597	1,05817	1,23376	1,09469	0,74799	1,44139	447,06230
Adjusted values	0	1,14597	1,05817	1,23376	1,09469	0,74799	1,44139	447,06230

Figure 5. Trim and Fill

The findings of trim and fill indicate that there is no difference or opposite according to the fixed effect model, so no research or study is trimmed or added to this study.. The overall effect size is 1.14597 rounded up to 1.146 is a very high value for an effect size.

Furthermore, in addressing the following question, it is demonstrated that the estimation approach, as previously stated, matches the fixed effect model. This shows that the effect sizes of each study are varied, necessitating a detailed examination of the categorical factors influencing the association between the Jigsaw learning model and mathematical competence. As a result, Table 2 shows the summary results of the category variable analysis.

Table 2. Summary of Category Variable Analysis

No	Category Variable	Group	N	Combined Effect Size (Hedge's g)	Test of null (2-Tail)		Heterogeneity		P-value	Decision
					Z	P-value	Between-Classes Effect (Q-value)	Df (Q)		
1	Country	Indonesia	15	0.99	3.439	0.001	0.331	1	0.565	Reject $H_0$
		Overseas	15	1.199	5.412	0				
		University	4	1.172	3.797	0				
2	Educational level	High School	9	0.942	3.672	0	32.466	4	0	Reject $H_0$
		Primary School	15	1.09	3.702	0.000				
		Elementary	1	2.924	8.428	0.000				
		Pre School	1	0.429	1.429	0.153				
3	Sample Size	30 or less	7	0.114	0.361	0.000	12.005	1	0.001	Reject $H_0$
		31 or more	23	1.384	7.51	0.000				
4	Publication Source	Journal	29	0.178	5.919	0.000	19.84	1	0	Reject $H_0$
		Proceding	1	2.26	11.07	0.000				

### **Country**

The effect size in Indonesian study was 3,439, whereas the effect size in international research was 5,412. According to the heterogeneity of  $Q$ -value = 0.331 and  $p > 0.05$ , studies on the Jigsaw learning model conducted in Indonesia and abroad have no impact on students' mathematical abilities.

### **Education Level**

According to Table 2, the sample size at the education level is as follows: Pre-school (0.429), Elementary (2.924), Junior High School (1.09), Senior High School (0.942), and University (1.172). Heterogeneity tests yielded  $Q$ -value = 32.466 and  $p > 0.05$ , indicating that the application of Jigsaw learning to mathematical abilities was influential at all stages of schooling, from pre-primary to university.

### **Sample Size**

Based on Table 2. It was shown that a sample size with a group of 30 or less had an effect size of 0.114, while a sample size with a group of 31 or more had an effect size of 1.384. Based on the heterogeneity test,  $Q$ -value = 12.005 and  $p < 0.05$ . In this situation, it suggests that the sample size influences Jigsaw technique learning with students' mathematical skills.

### **Publication Source**

According to the publication source, the effect size of journal research was 0.178, whereas the effect size of proceedings research was 2.26. Judging from the heterogeneity of  $Q$ -value = 19.84 and  $p < 0.05$ , the entire paper shows that Jigsaw learning affects students' mathematical abilities.

### **Discussion**

Essentially, the purpose of this study is to determine whether the Jigsaw approach has a significant impact on students' mathematical abilities. Based on the analysis, an effect size of 1,146 was obtained, which shows that this study has a considerable influence. In accordance with the research that has been conducted, there is a possibility that students can contribute to solving problems in group discussions using the Jigsaw learning model, due to its significant influence (Tamur et al., 2021).

The number of subjects studied in this study was 1252 with an average of 69 people. In this case, the effect size of 1,146 shows that the Jigsaw method affects mathematical ability (Cohen et al., 2018). In line with other studies, learning using the Jigsaw method is more fun than ordinary learning because students can find information from other groups (Wardani, 2015). Next, researchers conducted an analysis based on categorical variables. It can be seen that the amount of the influence in this study is clarified beginning with the level of education, country, sample size, and publication source.

Analysis of country categories found that research in Indonesia and abroad showed no influence between the Jigsaw learning model on mathematical ability. In this study, the number of samples from 30 papers is comparable. This means that in addition to Indonesia, abroad this research has been carried out a lot even not a few who use modifications to the variables studied with the main variable being Jigsaw learning. For example, research (Abed et al., 2020) that predicts Jigsaw-type learning strategies on students' mathematics learning achievement. Furthermore, other data show that the Jigsaw technique of learning geometric information is more effective than the lecture method (Timayi et al., 2015). Another study related to Jigsaw learning in Turkey states that there is an influence on students' abilities in natural science laboratory practice (Karacop, 2017).

Next, analyze category variables related to education level. Judging from the comparison of the magnitude of the effect size between Pre-School: Elementary: Junior High: High School: University (0.429: 2.924: 1.09: 0.942: 1.172) the results show that learning the Jigsaw method has a major effect on the elementary level. The findings also show that learning mathematics using the Jigsaw method is more effective at the elementary level than at other levels. According to research (Sulistiyowati & Astuti, 2020), the Jigsaw method of learning has a high level of cooperation as indicated by post-test and pre-test findings. Although this is a contradiction where learning mathematics using the Jigsaw method at the high school level affects students' mathematical

communication skills (Yeubun et al., 2020).

Learning mathematics using the Jigsaw method, as shown in Table 2, also demonstrates that many research samples were collected at the secondary school level. This happens because the level of thinking has entered the formal stage. On the other hand, this learning triggers the psychology of students to be curious about their peers (Utami et al., 2021). In addition to their mathematical abilities, students' mathematical successes have beneficial consequences after the Jigsaw learning approach is implemented (Ribut, 2021). However, other studies on cooperative learning with the type of Think Pair Share aided by comics show that it is no better than not using comics to develop problem-solving skills (Turyanto et al., 2019). However, Pair Check cooperative learning has been shown to improve students' overall cooperative abilities (Wijayanti & Kusdiyanta, 2019).

In this study, sample size was also applied to categorical variables to clarify the size of the effect on the study. The findings showed that (31 or more) had a greater influence than other categories. This study also conducted an analysis of publication sources on categorical variables. Based on the findings, 1 literature was obtained from proceedings and 29 other literature was obtained from journals. These data imply that the study was free of publication bias, which is supported by trim and fill.

Many studies are not taken or do not fall into the required category while examining this research. Such research conducted by (Budiawan & Arsani, 2013) using the same variables but carried out on sports subjects. In addition, there are also some unqualified studies where there is a lack of pretest data as a control study. Of the 500 data collected, only about 30 studies were included in the requirements after several screenings. And obviously, it does not end there; this study needs to be researched further to determine its effectiveness.

## CONCLUSION

This research was conducted by taking articles from proceedings and international journals in the range of 2010 – 2023. A meta-analysis research with 30 samples revealed a fixed effect with an effect size of 1,146, indicating that mastering the Jigsaw technique had a significant impact on students' mathematical abilities. This means that Jigsaw learning is still relevant to improve students' mathematical skills. Furthermore, this study was conducted analysis based on category variables divided into four variables. Based on the analysis of education levels, it was discovered that the degree of the influence varied depending on the study. However, learning using the Jigsaw method is more influential at the elementary level than other levels. In addition, the number of samples in 31 or more has a higher effectiveness and also publication sources based on journals have more significant influence, while analysis in countries does not have an influence on both research from Indonesia and abroad.

In the world of education, the application of the Jigsaw method is quite effective, as evidenced by the findings of several studies, particularly at the elementary level, where students enjoy playing and learning in groups, exchanging information, and working together to find information. This research has limitations because the sample in this study was obtained from Google Scholar using PoP software which means there are still many other research samples that were not carried out because of access or paid constraints. Further research requires good collaboration to review more deeply about this research.

## CONFLICT OF INTEREST

## ACKNOWLEDGEMENT

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**2. Bukti konfirmasi review dan hasil review pertama  
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# Is the Jigsaw Method Still Relevant for Improving Mathematical Ability? Meta-Analysis Studies

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## Abstract

Based on the findings of research that has been done, learning the Jigsaw method also has an influence on the mathematical ability of students but some do not have a significant influence. As a result, meta-analysis research is required to provide thorough and in-depth conclusions about the Jigsaw method's applicability to students' mathematical abilities. Comprehensive Meta-Analysis is used to evaluate property values based on comparisons with similar properties in the same area. Data obtained from Publish or Perish with a year level from 2010 to 2023 there are a total of 501 articles with a Google Scholar data base. The total number of eligible journals and will be analyzed is 30 samples with a total of 1252 subjects. The moderator variables in this study consider the country, education level, sample size and publication source. According to the study's findings, the Jigsaw technique had a significant impact on arithmetic ability (P-value 0.05), with an effect size of 1.146 classed as extremely high based on a fixed effect and an error standard of 0.045. The results showed that the Jigsaw method is still relevant to improve students' mathematical skills, especially at the elementary school level. In contrast, The meta-analysis revealed that the Jigsaw method had no effect on pupils' mathematical abilities across country categories.

**Keywords:** Jigsaw methods, mathematical abilities, meta-analysis

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## INTRODUCTION

Recognize mathematics as an abstract science that is the basis for achieving other sciences. Mathematics complements all existing sciences ranging from science, technology, art and many others (Kamarullah, 2017). The level of difficulty in mathematics is often used as a benchmark in achieving success. No wonder many of the nation's students are required to be proficient in mathematics. Sometimes the difficulty in solving abstract problems often makes interest in learning decrease so that you are lazy to learn, this is a trigger factor for problems in learning (Siswono, 2014). In mathematics, mathematical ability is not only measured on one ability. Mathematical abilities are grouped into five understandings ranging from mathematical understanding, problem solving, reasoning, connection and communication (Sumarmo, 2012). Mathematics learning must instill rational thinking processes with the laws of mathematical logic to develop thinking processes in solving mathematical problems (Maarif et al., 2018). In understanding logic, of course, requires motivation and good learning and teaching. Not all teaching provided is able to make some students interested in learning. Therefore, as a good teacher, there needs to be variety in providing learning models. This variant is used to ensure the learners grasp the topic and that objectives for learning are achieved. Currently, there are many learning models that are often found, ranging from Problem Based Learning (PBL), Project Based Learning (PJBL), Realistic Mathematics Education (RME), to Cooperative Learning (CL). The development of technology, a lot of research related to learning. In fact, not a few studies that vary learning with other methods.

Cooperative learning was first studied in 1898 by Roger and Johnson in about 600 experiments. Cooperative learning is learning that creates interaction between group members and teachers try to condition it by motivating students to always develop a sense of mutual need in a team (Jaelani, 2015). Social behavior learning is specifically developed to assist students in collaborating while learning. Cooperative learning is a learning paradigm in which students participate and interact

with one another in small groups of four to six persons (Saputra et al., 2017). There are various variations of models that can be used in cooperative learning, namely (1) STAD, (2) Group Investigation, (3) Jigsaw, (4) Think-Pair-Share, (5) Inside-Outside Circle, (6) Make a Match, (7) Listening Team, (8) The Power of Two, and (9) Bamboo Dancing.

Jigsaw is one of the models of cooperative learning. Jigsaw type learning is learning in a learning group where there is interaction between each group member and has responsibility for the material in the group and the ability to master and teach the topic to the other members of the group (Lubis & Harahap, 2016). The initial group and the expert group are displayed in the puzzle cooperative learning paradigm. The origin group, or parent group of students, consists of students from different racial, ethnic, and socioeconomic backgrounds. While the expert group consists of members of different origin groups and is tasked with researching and studying certain subjects while carrying out tasks that will be communicated to members of the origin group. A number of specialists from the initial group have been combined to form the expert group. Being interconnected with each other where each student is able to convey the information needed to their teammates so that the goal in solving problems can be achieved is the key to the success of Jigsaw (Werdiningsih & Mukhlisin, 2021). In this learning students work in a team and are assigned to read and study a subject. Random selection is made for each member of the group who is designated as an expert in a particular field. Furthermore, the experts reported to the group and met with other groups to discuss the material learned then returned to their group to teach the material to their teammates (Widyastuti, 2015). The characteristic of the Jigsaw type that distinguishes it from other types of cooperatives is that there are study groups and specialist groups (Hibattulloh & Sofyan, 2014).

One of the learning models that can promote student activity, involvement, and knowledge of the material is cooperative learning. The Jigsaw cooperative learning model is one example (Nurfitriyanti, 2017). This learning model is possible to be applied to young children, because this type of children is also divided into several heterogeneous groups according to ability and gender, so that group characters are formed into parallels (Poerwati et al., 2020). The Jigsaw cooperative paradigm is intended to improve students' problem-solving and critical thinking abilities because in discussion activities students are grouped into specialist groups and origin teams to solve mathematical problems (Handayani, 2020).

In understanding abstract science, the ability to train critical thinking needs to be taught to students (Sarman & Soebagyo, 2022). Critical thinking is the ability of human thinking that has systematic and logical steps (Saviraningrum & Soebagyo, 2022). Thinking logically means being precise, which is an important skill for life and work to work effectively in all areas of life. The advantage in critical thinking, we can assess the level of thoroughness or truth of the question and without any information it is not easy to express what we want to convey (Zuharni, 2022). In addition, mathematical creative thinking skills, namely the ability to think based on data and information, are available to find possible answers to such problems from different points of view on problems in each individual where it is more emphasized the suitability of answers and the versatility of answers (Yayuk et al., 2020). That is, creative thinking skills should belong to everyone (Florentina & Leonard, 2017). No less important, to find relationships from a representation of concepts and procedures, to grasp between mathematical themes and apply mathematical concepts in other fields or daily life, the capacity to make mathematical connections is required (Widarti, 2013).

The Jigsaw method of learning, which is derived from research findings, assists students in understanding the findings they make (Sari & Fitriani, 2018). In other studies there is an influence on the mathematical ability of students but there are also those that do not have a significant influence. Of course, in various studies there are different kinds of conclusions even though the variables studied have similarities. Based on the existing problems, Meta-analysts can provide comprehensive and in-depth conclusions on certain variables or topics that want to be discussed. This study can answer how much influence the Jigsaw method has based on the desired category variables. One of the results of this study is a significant improvement in students' mathematical abilities after attending the Jigsaw method lecture with discussion assessment and based only on the findings of the preliminary and final tests (Edriati et al., 2015).

## METHODS

The data screening in this investigation was done using the PRISMA protocols shown in Figure 2.

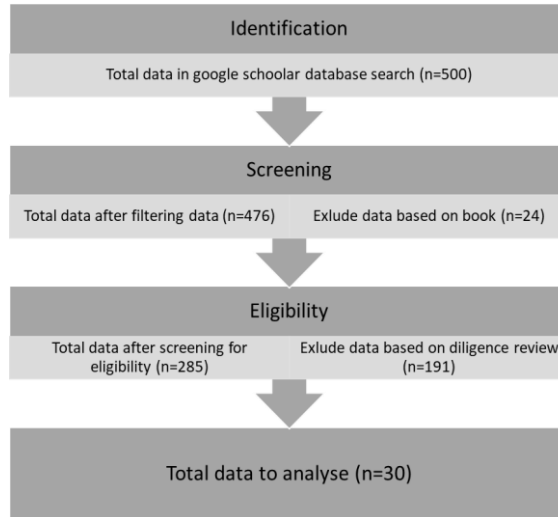


Figure 7. Filter data using PRISMA

### Coding

All studies that match the criteria are coded manually using a detailed coding scheme based on protocols. In this study, the instrument was carried out using the provision of codes (*categories*). Coding is done to separate individual data information into numerical data. A random sample of 5 valid studies was reproduced and divided among coders to determine reliability. The coder is given a copy of the article, as well as the coding form and protocol. To assess the reliability of these coders, the following formula is employed to calculate percent agreement (PA):

$$PA = \frac{N_A}{N_A + N_P} \times 100\%$$

In this scenario,  $N_A$  represents the total number of agreements, while  $N_P$  represents the entire number of disagreements.

### Statistical Analysis

The data was evaluated with the CMA application, with special attention paid to the effect size, which is defined as the influence of the Jigsaw approach on students' mathematical skills. The Comprehensive Meta-Analysis is beneficial for adjusting the effect size of research, including the overall effect size, P-value, Q-statistic, and truth interval. In addition, the program creates research forest plots and funnel plots. The g Hedges measure was utilized in this analysis, and the size effect was classified as less than 0.2 (negligible), 0.2 to 0.5 (small effect), 0.5 to 0.8 (moderate effect), 0.8 to 1.3 (big effect), and more than 1.3 (very large effect) (Cohen et al., 2007). The random effect technique was chosen as the estimation method since there is no assumption that all research have the same effect. The randomized effect model in this study was selected after a successful heterogeneity test. The p value is used to perform this test. If the p-value is less than 0.05, all studies will be identical, and the null hypothesis and homogeneity will be rejected. The rejection of the null hypothesis suggests that population parameters may not be measured with the same effect size across studies or study groups (Retnawati et al., 2018). There is evidence that different study categories have different effects on study effect sizes.

To avoid misrepresentation of results, publication bias is checked. Publication bias is the likelihood that studies appearing in published literature are considered statistically significant to be published (Cooper et al., 2009). In anticipation, a bias analysis was carried out on the funnel plot to see if the research was free from bias. When the distribution of impact sizes on vertical lines was symmetrical, publication bias was judged strong in this study. However, if the size distribution of the effect is not perfectly symmetrical, it is necessary to use the trim and fill method. If the observed

effects and virtual effects generated by randomized effects models are found to be similar, then the study is immune to publication bias.

## **RESULTS & DISCUSSION**

### ***Results***

#### **Literature Search Results**

The goal of this study was to determine whether the magnitude of the effect created had an effect on learning the Jigsaw method and mathematical competence based on category variables. Therefore, researchers try to search literature using PoP (Publish or Perish) software by applying several criteria. The first criterion, researchers use vulnerable research time in 2010 – 2023. Furthermore, the second criterion of researchers used the keywords Jigsaw and Math ability, and the maximum number of results was limited to 500 data. From the topics used, 501 articles were collected, with 24 data coming from books and the rest coming from journals, citations and documents.

#### **Literature Selection Results**

After setting criteria for literature search, the researcher converts the data into excel and eliminates the data in the appropriate journal. First, researchers filter data that is included in journals or articles. Second, researchers use a quantitative approach to collect data that has an experimental class and a control class. Third, researchers collect statistical data such as the number of samples, average values and standard deviations. This statistical data aims to calculate the size of the effect to be studied. Furthermore, screening through the PRISMA method is carried out to ensure the accuracy of the data obtained. Not only that, but researchers must guarantee that the journal's title and theme are consistent with the criteria variables.

#### **Results Criteria**

The results of the criteria in this study focused on vulnerable years 2010 - 2023. The selection of criteria on this year's vulnerability was carried out to ensure that the available research is up-to-date. From the results of the criteria that have been filtered, researchers consider choosing research sourced from journals and proceedings. In addition, researchers also obtained various journals from various countries with the same topic, ranging from Asian to European countries. Furthermore, researchers consider the degree of education beginning with (pre-school, elementary, junior high, high school, and university). The many variations that have been studied at this level of education add to the accuracy of a study. Furthermore, researchers also looked at the number of sample sizes in a study and paid attention to whether each of these journals had a control class and an experimental class. The selected research is also equipped with post-test and pre-test data, average values and standard deviations to see the extent of the data spread and whether there are data deviations in the average value.

#### **Statistical Analysis Results**

The results of the study here aim to answer the research question. Figure 3 depicts the findings of a meta-analysis of 30 filtered and collected data from Google Scholar. Figure 3 contains the identification of the names of the studies. Furthermore, the magnitude of the effect is shown which contains the results of the intervention. It can be seen that there is 1 data that is less than 0 or under consideration, while the average confidence interval that stretches horizontally or is more than 0 is on the right. This means that the effects of the intervention are beneficial. In addition, figure 3 also shows the heterogeneity of a data to see discrepancies in the source of findings from the study.

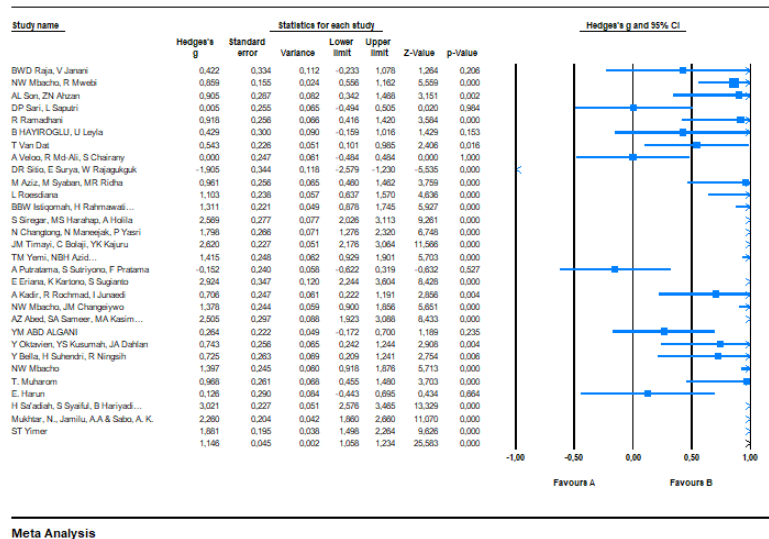


Figure 8. Research Forest Plot

According to Figure 3, there is an inconsistent response rate. It is clear that the research is likely to be diverse. As a result, it must be statistically examined such that the starting assumptions are consistent with the estimation approach.

Table 3. Meta Results - Analysis according to the Estimation method

Model	N	Hedge's g	Standard error	Test of null		Q	P	Decision
				Z-value	P-value			
Fixed-effects	30	1.146	0.045	25.583	0.000	447.062	0.000	Reject
Random-effects	30	1.095	0.177	6.189	0.000			

Table 1 displays the findings of a meta-analysis of 30 papers from conferences and international journals. Table 1 shows that the P value is 0.05, indicating that each study has a diverse impact size. Therefore, a fixed effect model with a very high effect size of 1,146 was used. Using a null test obtained P less than 0.05 with a fixed effects model. In addition, a z value of 25,583 was obtained indicating that the research results were significant for  $P < 0.05$  (Musna et al., 2021). To put it another way, the Jigsaw-type learning model has a big impact on mathematical ability.

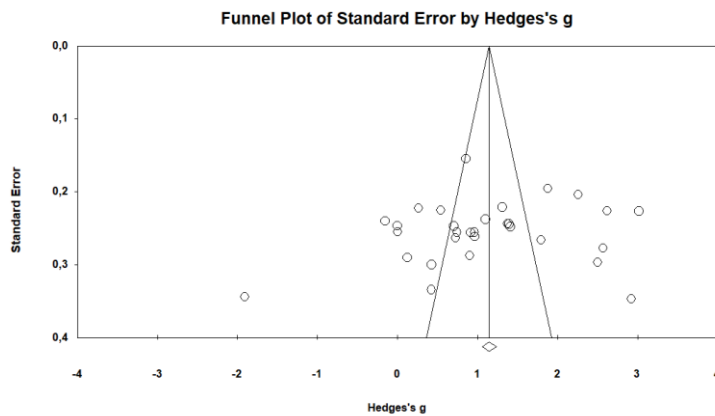


Figure 9. Funnel plot of 30 samples

Then, as shown in Figure 5, we will show a funnel plot with the research spread out and not symmetrical in the funnel, requiring trim and fill to check whether there is a difference with the influence of publication bias.

#### Duval and Tweedie's trim and fill

	Studies Trimmed	Fixed Effects			Random Effects			Q Value
		Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit	
Observed values		1,14597	1,05817	1,23376	1,09469	0,74799	1,44139	447,06230
Adjusted values	0	1,14597	1,05817	1,23376	1,09469	0,74799	1,44139	447,06230

Figure 10. Trim and Fill

The findings of trim and fill indicate that there is no difference or opposite according to the fixed effect model, so no research or study is trimmed or added to this study.. The overall effect size is 1.14597 rounded up to 1.146 is a very high value for an effect size.

Furthermore, in addressing the following question, it is demonstrated that the estimation approach, as previously stated, matches the fixed effect model. This shows that the effect sizes of each study are varied, necessitating a detailed examination of the categorical factors influencing the association between the Jigsaw learning model and mathematical competence. As a result, Table 2 shows the summary results of the category variable analysis.

Table 4. Summary of Category Variable Analysis

No	Category Variable	Group	N	Combined Effect Size (Hedge's g)	Test of null (2-Tail)		Heterogeneity		P-value	Decision
					Z	P-value	Between-Classes Effect (Q-value)	Df (Q)		
1	Country	Indonesia	15	0.99	3.439	0.001	0.331	1	0.565	Reject $H_0$
		Overseas	15	1.199	5.412	0				
2	Educational level	University	4	1.172	3.797	0	32.466	4	0	Reject $H_0$
		High School	9	0.942	3.672	0				
		Primary School	15	1.09	3.702	0.000				
		Elementary	1	2.924	8.428	0.000				
		Pre School	1	0.429	1.429	0.153				
3	Sample Size	30 or less	7	0.114	0.361	0.000	12.005	1	0.001	Reject $H_0$
		31 or more	23	1.384	7.51	0.000				
4	Publication Source	Journal	29	0.178	5.919	0.000	19.84	1	0	Reject $H_0$
		Proceding	1	2.26	11.07	0.000				



### **Country**

The effect size in Indonesian study was 3,439, whereas the effect size in international research was 5,412. According to the heterogeneity of  $Q$ -value = 0.331 and  $p > 0.05$ , studies on the Jigsaw learning model conducted in Indonesia and abroad have no impact on students' mathematical abilities.

### **Education Level**

According to Table 2, the sample size at the education level is as follows: Pre-school (0.429), Elementary (2.924), Junior High School (1.09), Senior High School (0.942), and University (1.172). Heterogeneity tests yielded  $Q$ -value = 32.466 and  $p > 0.05$ , indicating that the application of Jigsaw learning to mathematical abilities was influential at all stages of schooling, from pre-primary to university.

### **Sample Size**

Based on Table 2. It was shown that a sample size with a group of 30 or less had an effect size of 0.114, while a sample size with a group of 31 or more had an effect size of 1.384. Based on the heterogeneity test,  $Q$ -value = 12.005 and  $p < 0.05$ . In this situation, it suggests that the sample size influences Jigsaw technique learning with students' mathematical skills.

### **Publication Source**

According to the publication source, the effect size of journal research was 0.178, whereas the effect size of proceedings research was 2.26. Judging from the heterogeneity of  $Q$ -value = 19.84 and  $p < 0.05$ , the entire paper shows that Jigsaw learning affects students' mathematical abilities.

### **Discussion**

Essentially, the purpose of this study is to determine whether the Jigsaw approach has a significant impact on students' mathematical abilities. Based on the analysis, an effect size of 1,146 was obtained, which shows that this study has a considerable influence. In accordance with the research that has been conducted, there is a possibility that students can contribute to solving problems in group discussions using the Jigsaw learning model, due to its significant influence (Tamur et al., 2021).

The number of subjects studied in this study was 1252 with an average of 69 people. In this case, the effect size of 1,146 shows that the Jigsaw method affects mathematical ability (Cohen et al., 2018). In line with other studies, learning using the Jigsaw method is more fun than ordinary learning because students can find information from other groups (Wardani, 2015). Next, researchers conducted an analysis based on categorical variables. It can be seen that the amount of the influence in this study is clarified beginning with the level of education, country, sample size, and publication source.

Analysis of country categories found that research in Indonesia and abroad showed no influence between the Jigsaw learning model on mathematical ability. In this study, the number of samples from 30 papers is comparable. This means that in addition to Indonesia, abroad this research has been carried out a lot even not a few who use modifications to the variables studied with the main variable being Jigsaw learning. For example, research (Abed et al., 2020) that predicts Jigsaw-type learning strategies on students' mathematics learning achievement. Furthermore, other data show that the Jigsaw technique of learning geometric information is more effective than the lecture method (Timayi et al., 2015). Another study related to Jigsaw learning in Turkey states that there is an influence on students' abilities in natural science laboratory practice (Karacop, 2017).

Next, analyze category variables related to education level. Judging from the comparison of the magnitude of the effect size between Pre-School: Elementary: Junior High: High School: University (0.429: 2.924: 1.09: 0.942: 1.172) the results show that learning the Jigsaw method has a major effect on the elementary level. The findings also show that learning mathematics using the Jigsaw method is more effective at the elementary level than at other levels. According to research (Sulistiyowati & Astuti, 2020), the Jigsaw method of learning has a high level of cooperation as indicated by post-test and pre-test findings. Although this is a contradiction where learning mathematics using the Jigsaw method at the high school level affects students' mathematical

communication skills (Yeubun et al., 2020).

Learning mathematics using the Jigsaw method, as shown in Table 2, also demonstrates that many research samples were collected at the secondary school level. This happens because the level of thinking has entered the formal stage. On the other hand, this learning triggers the psychology of students to be curious about their peers (Utami et al., 2021). In addition to their mathematical abilities, students' mathematical successes have beneficial consequences after the Jigsaw learning approach is implemented (Ribut, 2021). However, other studies on cooperative learning with the type of Think Pair Share aided by comics show that it is no better than not using comics to develop problem-solving skills (Turyanto et al., 2019). However, Pair Check cooperative learning has been shown to improve students' overall cooperative abilities (Wijayanti & Kusdiyanta, 2019).

In this study, sample size was also applied to categorical variables to clarify the size of the effect on the study. The findings showed that (31 or more) had a greater influence than other categories. This study also conducted an analysis of publication sources on categorical variables. Based on the findings, 1 literature was obtained from proceedings and 29 other literature was obtained from journals. These data imply that the study was free of publication bias, which is supported by trim and fill.

Many studies are not taken or do not fall into the required category while examining this research. Such research conducted by (Budiawan & Arsani, 2013) using the same variables but carried out on sports subjects. In addition, there are also some unqualified studies where there is a lack of pretest data as a control study. Of the 500 data collected, only about 30 studies were included in the requirements after several screenings. And obviously, it does not end there; this study needs to be researched further to determine its effectiveness.

## CONCLUSION

This research was conducted by taking articles from proceedings and international journals in the range of 2010 – 2023. A meta-analysis research with 30 samples revealed a fixed effect with an effect size of 1,146, indicating that mastering the Jigsaw technique had a significant impact on students' mathematical abilities. This means that Jigsaw learning is still relevant to improve students' mathematical skills. Furthermore, this study was conducted analysis based on category variables divided into four variables. Based on the analysis of education levels, it was discovered that the degree of the influence varied depending on the study. However, learning using the Jigsaw method is more influential at the elementary level than other levels. In addition, the number of samples in 31 or more has a higher effectiveness and also publication sources based on journals have more significant influence, while analysis in countries does not have an influence on both research from Indonesia and abroad.

In the world of education, the application of the Jigsaw method is quite effective, as evidenced by the findings of several studies, particularly at the elementary level, where students enjoy playing and learning in groups, exchanging information, and working together to find information. This research has limitations because the sample in this study was obtained from Google Scholar using PoP software which means there are still many other research samples that were not carried out because of access or paid constraints. Further research requires good collaboration to review more deeply about this research.

## CONFLICT OF INTEREST

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# Is the Jigsaw Method Still Relevant for Improving Mathematical Skills? Meta-Analysis Study

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## Abstract

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Based on the findings of research that has been done, learning the Jigsaw method also has an influence on the mathematical ability of students but some do not have a significant influence. As a result, meta-analysis research is required to provide thorough and in-depth conclusions about the Jigsaw method's applicability to students' mathematical abilities. Comprehensive Meta-Analysis is used to evaluate property values based on comparisons with similar properties in the same area. Data obtained from Publish or Perish with a year level from 2010 to 2023 there are a total of 501 articles with a Google Scholar data base. The total number of eligible journals and will be analyzed is 30 samples with a total of 1252 subjects. The moderator variables in this study consider the country, education level, sample size and publication source. According to the study's findings, the Jigsaw technique had a significant impact on arithmetic ability (P-value 0.05), with an effect size of 1.146 classed as extremely high based on a fixed effect and an error standard of 0.045. The results showed that the Jigsaw method is still relevant to improve students' mathematical skills, especially at the elementary school level. In contrast, The meta-analysis revealed that the Jigsaw method had no effect on pupils' mathematical abilities across country categories.

**Keywords:** Jigsaw methods, mathematical abilities, meta-analysis

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## INTRODUCTION

Recognize mathematics as an abstract science that is the basis for achieving other sciences. Mathematics complements all existing sciences ranging from science, technology, art and many others (Kamarullah, 2017). The level of difficulty in mathematics is often used as a benchmark in achieving success. No wonder many of the nation's students are required to be proficient in mathematics. Sometimes the difficulty in solving abstract problems often makes interest in learning decrease so that you are lazy to learn, this is a trigger factor for problems in learning (Siswono, 2014). In mathematics, mathematical ability is not only measured on one ability. Mathematical abilities are grouped into five understandings ranging from mathematical understanding, problem solving, reasoning, connection and communication (Sumarmo, 2012). In understanding logic, of course, requires motivation and good learning and teaching. Not all teaching provided is able to make some students interested in learning. Therefore, as a good teacher, there needs to be variety in providing learning models. This variant is used to ensure the learners grasp the topic and that objectives for learning are achieved. Currently, there are many learning models that are often found, ranging from Problem Based Learning (PBL), Project Based Learning (PJBL), Realistic Mathematics Education (RME), to Cooperative Learning (CL). The development of technology, a lot of research related to learning. In fact, not a few studies that vary learning with other methods.

Cooperative learning was first studied in 1898 by Roger and Johnson in about 600 experiments. Cooperative learning is learning that creates interaction between group members and teachers try to condition it by motivating students to always develop a sense of mutual need in a team (Jaelani, 2015). Social behavior learning is specifically developed to assist students in collaborating while learning. Cooperative learning is a learning paradigm in which students participate and interact



with one another in small groups of four to six persons (Saputra et al., 2017). There are various variations of models that can be used in cooperative learning, namely (1) STAD, (2) Group Investigation, (3) Jigsaw, (4) Think-Pair-Share, (5) Inside-Outside Circle, (6) Make a Match, (7) Listening Team, (8) The Power of Two, and (9) Bamboo Dancing.

Jigsaw is one of the models of cooperative learning. Jigsaw type learning is learning in a learning group where there is interaction between each group member and has responsibility for the material in the group and the ability to master and teach the topic to the other members of the group (Lubis & Harahap, 2016). The initial group and the expert group are displayed in the puzzle cooperative learning paradigm. The origin group, or parent group of students, consists of students from different racial, ethnic, and socioeconomic backgrounds. While the expert group consists of members of different origin groups and is tasked with researching and studying certain subjects while carrying out tasks that will be communicated to members of the origin group. A number of specialists from the initial group have been combined to form the expert group. Being interconnected with each other where each student is able to convey the information needed to their teammates so that the goal in solving problems can be achieved is the key to the success of Jigsaw (Werdiningsih & Mukhlisin, 2021). In this learning students work in a team and are assigned to read and study a subject. Random selection is made for each member of the group who is designated as an expert in a particular field. Furthermore, the experts reported to the group and met with other groups to discuss the material learned then returned to their group to teach the material to their teammates (Widyastuti, 2015). The characteristic of the Jigsaw type that distinguishes it from other types of cooperatives is that there are study groups and specialist groups (Hibattulloh & Sofyan, 2014).

One of the learning models that can promote student activity, involvement, and knowledge of the material is cooperative learning. The Jigsaw cooperative learning model is one example (Nurfityanti, 2017). This learning model is possible to be applied to young children, because this type of children is also divided into several heterogeneous groups according to ability and gender, so that group characters are formed into parallels (Poerwati et al., 2020). The Jigsaw cooperative paradigm is intended to improve students' problem-solving and critical thinking abilities because in discussion activities students are grouped into specialist groups and origin teams to solve mathematical problems (Handayani, 2020).

In understanding abstract science, the ability to train critical thinking needs to be taught to students. Critical thinking is the ability of human thinking that has systematic and logical steps. Thinking logically means being precise, which is an important skill for life and work to work effectively in all areas of life. The advantage in critical thinking, we can assess the level of thoroughness or truth of the question and without any information it is not easy to express what we want to convey (Zuharni, 2022). In addition, mathematical creative thinking skills, namely the ability to think based on data and information, are available to find possible answers to such problems from different points of view on problems in each individual where it is more emphasized the suitability of answers and the versatility of answers. That is, creative thinking skills should belong to everyone (Florentina & Leonard, 2017). No less important, to find relationships from a representation of concepts and procedures, to grasp between mathematical themes and apply mathematical concepts in other fields or daily life, the capacity to make mathematical connections is required (Widarti, 2013).

The Jigsaw method of learning, which is derived from research findings, assists students in understanding the findings they make (Sari & Fitriani, 2018). In other studies there is an influence on the mathematical ability of students but there are also those that do not have a significant influence. Of course, in various studies there are different kinds of conclusions even though the variables studied have similarities. Based on the existing problems, Meta-analysts can provide comprehensive and in-depth conclusions on certain variables or topics that want to be discussed. This study can answer how much influence the Jigsaw method has based on the desired category variables. One of the results of this study is a significant improvement in students' mathematical abilities after attending the Jigsaw method lecture with discussion assessment and based only on the findings of the preliminary and final tests (Edriati et al., 2015).

## METHODS

This study focuses on quantitative data research analysis based on Google Scholar database sources, specifically to investigate *Jigsaw models* with *math ability*. The purpose of this analysis was to identify the magnitude of the influence on the Jigsaw learning method and to investigate the impact of characteristics on mathematical ability in determining the variation in effect size of each available research. Analysis using a meta-analysis approach is used to achieve this purpose. Meta-analysis is used to compare primary study with other scientific advancements in the form of drawing statistical findings in the form of effect size on quantitative data studies based on relevant themes (Rosdiana, 2021). The steps in compiling the meta-analysis, starting from; (1) choose the criteria for the article to be researched, (2) look for literature sources related to relevant research to be used, (3) code the article to be used, (4) conduct analysis and classification, (5) interpret findings based on the article under study (Sukmawati, 2020).

### Literary Search

This research uses the Google Scholar database as a location for document search. Furthermore, the use of Publish or Perish is applied as a reference in downloading studies related to the application of the Jigsaw method by combining keywords into Jigsaw, math ability (Eryanti & Soebagyo, 2021; Haniyah & Soebagyo, 2021; Sarman & Soebagyo, 2022). Seen in Figure 1, it is obtained that the search process for the application of the Jigsaw method on Google Scholar using the PoP application reaches 500 data.

The screenshot shows the Google Scholar search interface. At the top, search terms are listed: 'jigsaw, math ability from 2010 to 2023'. Below this, a table displays search results with columns for Cites, Per year, Rank, Authors, Title, Year, Publication, Publisher, and Type. The first few results are visible, showing various studies related to jigsaw learning and mathematical ability.

Cites	Per year	Rank	Authors	Title	Year	Publication	Publisher	Type
9	3.00	1	N Rambe, E Syahputra	The Effect of the Jigsaw Cooperative Learning Model on the Mathematical Ability of Students in the Class of Elementary School	2020	Journal of Education and Didactic Research	gajournal.uns.ac.id	PDF
41	5.86	2	Dewi, M, Hidayat	The Effect of Jigsaw Cooperative Learning Model on the Mathematical Ability of Students in the Class of Elementary School	2016	Journal of Education and Didactic Research	gajournal.uns.ac.id	PDF
14	2.80	3	S Sumartono, D Darhi	The students' mathematical communication ability in solving mathematical problems	2018	Journal of Physics: Conference Series	iopscience.iop.org	PDF
34	6.80	4	DP Sari, E Syahputra	An analysis of spatial ability and mathematical ability in solving mathematical problems	2018	American Journal of Mathematics Education	article.ajmedjournal.com	PDF
22	2.75	5	S Ertanto, V Anggraini	Effectiveness Model Jigsaw Cooperative Learning Model in Improving Mathematical Ability of Students	2015	Jurnal Cakrawala Pendidikan	jurnal.uns.ac.id	PDF
4	1.33	6	AH Dians, D Djojonegoro	Mathematical creative thinking ability in solving mathematical problems	2020	Unnes Journal of Mathematics Education	jurnal.unnes.ac.id	PDF
25	6.25	7	E Eriana, K Kartono	Understanding Ability of Mathematics in Solving Mathematical Problems	2019	Journal of Primary Education	jurnal.unnes.ac.id	PDF
2	0.67	8	US Nuzul, A Nuzul	The Effect of Jigsaw Cooperative Learning Model on the Mathematical Ability of Students	2020	Forum: Jurnal Ilmiah Pendidikan	jurnal.fkip.uns.ac.id	PDF
9	4.00	9	H Sa'adah, S Syahputra	Student team achievement division (STAD) model in improving mathematical ability	2021	Decentral Journal	jurnal.decentral.ac.id	PDF
46	5.75	10	F Masrudi, A Riyanto	The discrepancy of students' mathematical ability in solving mathematical problems	2015	International Journal of Mathematics Education in Science and Technology	ijmest.com	PDF
1	0.20	11	DR Satrio, E Suryo	The Effect of Jigsaw Cooperative Learning Model on the Mathematical Ability of Students	2018	3rd Annual International Conference on Mathematics Education	attentio-press.com	PDF
19	2.11	12	K Iqbal, M Iqbal	Meningkatkan Kemampuan Pemahaman dan Penalaran Matematis Siswa dengan Model Jigsaw	2014	Jurnal Didaktika Matematika	jurnal.uns.ac.id	PDF
21	2.33	13	C Young, E Catherino	Gestures and speech input are interrelated in the learning process	2014	Proceedings of the 1st International Conference on Mathematics Education	escholarship.org	PDF
40	5.45	14	C Darmas, C Bachtiar	The Jigsaw technique and self-efficacy in improving mathematical ability	2012	European Journal of Mathematics Education	springer	PDF
44	11.00	15	R Faras, C Mulyono	Visual and spatial working memory in solving mathematical problems	2019	Frontiers in Psychology	frontiersin.org	HTML
14	2.33	16	M Juliana, E Suryo	An Analysis of Jigsaw Cooperative Learning Model in Improving Mathematical Ability	2017	Journal of Advanced Research in Mathematics	researchgate.net	PDF
4	0.80	17	Ak Satrio, H Mulyono	THE DIFFERENCE OF STUDENTS' MATHEMATICAL ABILITY IN SOLVING MATHEMATICAL PROBLEMS	2018	Journal of Mathematics Education in Science and Technology	com.ac.id	PDF
5	1.00	18	Ak Satrio, H Mulyono	OF STUDENTS' ACHIEVEMENT IN SOLVING MATHEMATICAL PROBLEMS	2018	Infinity Journal	ejournal.diklatkangsiang.ac.id	PDF

Figure 11. Google Scholar database search results (Jigsaw, Math ability)

### Literary Inclusion Criteria

Throughout the present investigation, the research that was successfully found using the PoP software was then collated based on the requirements listed following: (1) write keywords using English settings, then retrieve the Google Scholar database at a vulnerable time between 2010-2023, (2) statistical information is used to obtain the effect size value. And journals or study criteria that do not match will be removed from the analysis data, and (3) learning to use a quantitative approach where in quantitative data there must be control groups and experiments. Journals or papers with just a single sample and a qualitative approach will be excluded from the data analysis.

The data screening in this investigation was done using the PRISMA protocols shown in Figure 2.

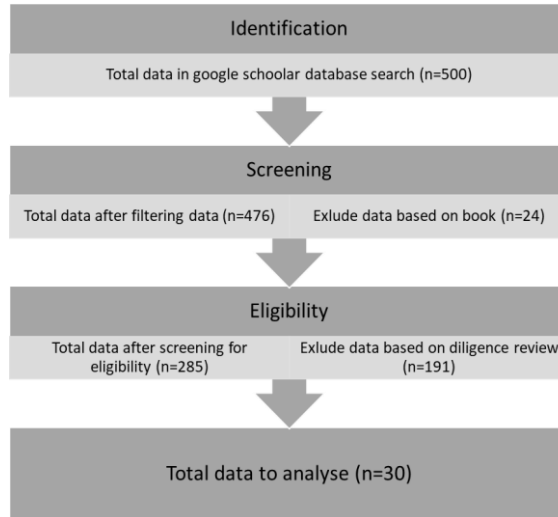


Figure 12. Filter data using PRISMA

### Coding

All studies that match the criteria are coded manually using a detailed coding scheme based on protocols. In this study, the instrument was carried out using the provision of codes (*categories*). Coding is done to separate individual data information into numerical data. A random sample of 5 valid studies was reproduced and divided among coders to determine reliability. The coder is given a copy of the article, as well as the coding form and protocol. To assess the reliability of these coders, the following formula is employed to calculate percent agreement (PA):

$$PA = \frac{N_A}{N_A + N_P} \times 100\%$$

In this scenario,  $N_A$  represents the total number of agreements, while  $N_P$  represents the entire number of disagreements.

### Statistical Analysis

The data was evaluated with the CMA application, with special attention paid to the effect size, which is defined as the influence of the Jigsaw approach on students' mathematical skills. The Comprehensive Meta-Analysis is beneficial for adjusting the effect size of research, including the overall effect size, P-value, Q-statistic, and truth interval. In addition, the program creates research forest plots and funnel plots. The g Hedges measure was utilized in this analysis, and the size effect was classified as less than 0.2 (negligible), 0.2 to 0.5 (small effect), 0.5 to 0.8 (moderate effect), 0.8 to 1.3 (big effect), and more than 1.3 (very large effect) (Cohen et al., 2007). The random effect technique was chosen as the estimation method since there is no assumption that all research have the same effect. The randomized effect model in this study was selected after a successful heterogeneity test. The p value is used to perform this test. If the p-value is less than 0.05, all studies will be identical, and the null hypothesis and homogeneity will be rejected. The rejection of the null hypothesis suggests that population parameters may not be measured with the same effect size across studies or study groups (Retnawati et al., 2018). There is evidence that different study categories have different effects on study effect sizes.

To avoid misrepresentation of results, publication bias is checked. Publication bias is the likelihood that studies appearing in published literature are considered statistically significant to be published (Cooper et al., 2009). In anticipation, a bias analysis was carried out on the funnel plot to see if the research was free from bias. When the distribution of impact sizes on vertical lines was symmetrical, publication bias was judged strong in this study. However, if the size distribution of the effect is not perfectly symmetrical, it is necessary to use the trim and fill method. If the observed

effects and virtual effects generated by randomized effects models are found to be similar, then the study is immune to publication bias.

## **RESULTS & DISCUSSION**

### ***Results***

#### **Literature Search Results**

The goal of this study was to determine whether the magnitude of the effect created had an effect on learning the Jigsaw method and mathematical competence based on category variables. Therefore, researchers try to search literature using PoP (Publish or Perish) software by applying several criteria. The first criterion, researchers use vulnerable research time in 2010 – 2023. Furthermore, the second criterion of researchers used the keywords Jigsaw and Math ability, and the maximum number of results was limited to 500 data. From the topics used, 501 articles were collected, with 24 data coming from books and the rest coming from journals, citations and documents.

#### **Literature Selection Results**

After setting criteria for literature search, the researcher converts the data into excel and eliminates the data in the appropriate journal. First, researchers filter data that is included in journals or articles. Second, researchers use a quantitative approach to collect data that has an experimental class and a control class. Third, researchers collect statistical data such as the number of samples, average values and standard deviations. This statistical data aims to calculate the size of the effect to be studied. Furthermore, screening through the PRISMA method is carried out to ensure the accuracy of the data obtained. Not only that, but researchers must guarantee that the journal's title and theme are consistent with the criteria variables.

#### **Results Criteria**

The results of the criteria in this study focused on vulnerable years 2010 - 2023. The selection of criteria on this year's vulnerability was carried out to ensure that the available research is up-to-date. From the results of the criteria that have been filtered, researchers consider choosing research sourced from journals and proceedings. In addition, researchers also obtained various journals from various countries with the same topic, ranging from Asian to European countries. Furthermore, researchers consider the degree of education beginning with (pre-school, elementary, junior high, high school, and university). The many variations that have been studied at this level of education add to the accuracy of a study. Furthermore, researchers also looked at the number of sample sizes in a study and paid attention to whether each of these journals had a control class and an experimental class. The selected research is also equipped with post-test and pre-test data, average values and standard deviations to see the extent of the data spread and whether there are data deviations in the average value.

#### **Statistical Analysis Results**

The results of the study here aim to answer the research question. Figure 3 depicts the findings of a meta-analysis of 30 filtered and collected data from Google Scholar. Figure 3 contains the identification of the names of the studies. Furthermore, the magnitude of the effect is shown which contains the results of the intervention. It can be seen that there is 1 data that is less than 0 or under consideration, while the average confidence interval that stretches horizontally or is more than 0 is on the right. This means that the effects of the intervention are beneficial. In addition, figure 3 also shows the heterogeneity of a data to see discrepancies in the source of findings from the study.

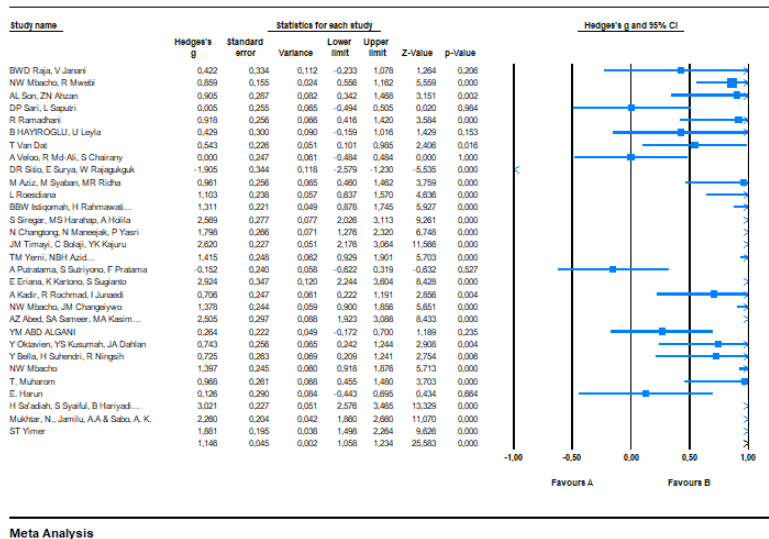


Figure 13. Research Forest Plot

According to Figure 3, there is an inconsistent response rate. It is clear that the research is likely to be diverse. As a result, it must be statistically examined such that the starting assumptions are consistent with the estimation approach.

Table 5. Meta Results - Analysis according to the Estimation method

Model	N	Hedge's	andard er	Test of null		Q	P	Decision
				Z-value	P-value			
Fixed-effects	30	1.146	0.045	25.583	0.000	447.062	0.000	Reject
Random-effects	30	1.095	0.177	6.189	0.000			

Table 1 displays the findings of a meta-analysis of 30 papers from conferences and international journals. Table 1 shows that the P value is 0.05, indicating that each study has a diverse impact size. Therefore, a fixed effect model with a very high effect size of 1,146 was used. Using a null test obtained P less than 0.05 with a fixed effects model. In addition, a z value of 25,583 was obtained indicating that the research results were significant for  $P < 0.05$  (Musna et al., 2021). To put it another way, the Jigsaw-type learning model has a big impact on mathematical ability.

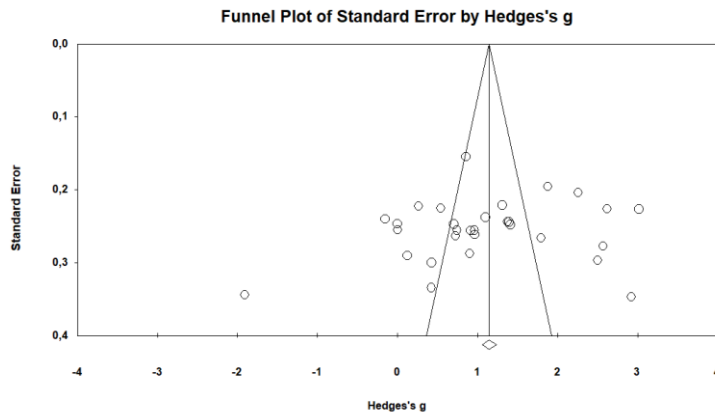


Figure 14. Funnel plot of 30 samples

Then, as shown in Figure 5, we will show a funnel plot with the research spread out and not symmetrical in the funnel, requiring trim and fill to check whether there is a difference with the influence of publication bias.

#### Duval and Tweedie's trim and fill

	Fixed Effects			Random Effects			Q Value
	Studies Trimmed	Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit
Observed values		1,14597	1,05817	1,23376	1,09469	0,74799	1,44139
Adjusted values	0	1,14597	1,05817	1,23376	1,09469	0,74799	1,44139

Figure 15. Trim and Fill

The findings of trim and fill indicate that there is no difference or opposite according to the fixed effect model, so no research or study is trimmed or added to this study.. The overall effect size is 1.14597 rounded up to 1.146 is a very high value for an effect size.

Furthermore, in addressing the following question, it is demonstrated that the estimation approach, as previously stated, matches the fixed effect model. This shows that the effect sizes of each study are varied, necessitating a detailed examination of the categorical factors influencing the association between the Jigsaw learning model and mathematical competence. As a result, Table 2 shows the summary results of the category variable analysis.

Table 6. Summary of Category Variable Analysis

No	Category Variable	Group	N	Combined Effect Size (Hedge's g)	Test of null (2-Tail)		Heterogeneity		P-value	Decision
					Z	P-value	Between-Classes Effect (Q-value)	Df (Q)		
1	Country	Indonesia	15	0.99	3.439	0.001	0.331	1	0.565	Reject $H_0$
		Overseas	15	1.199	5.412	0				
2	Educational level	University	4	1.172	3.797	0	32.466	4	0	Reject $H_0$
		High School	9	0.942	3.672	0				
		Primary School	15	1.09	3.702	0.000				
		Elementary	1	2.924	8.428	0.000				
		Pre School	1	0.429	1.429	0.153				
3	Sample Size	30 or less	7	0.114	0.361	0.000	12.005	1	0.001	Reject $H_0$
		31 or more	23	1.384	7.51	0.000				
4	Publication Source	Journal	29	0.178	5.919	0.000	19.84	1	0	Reject $H_0$
		Proceding	1	2.26	11.07	0.000				

### **Country**

The effect size in Indonesian study was 3,439, whereas the effect size in international research was 5,412. According to the heterogeneity of  $Q$ -value = 0.331 and  $p > 0.05$ , studies on the Jigsaw learning model conducted in Indonesia and abroad have no impact on students' mathematical abilities.

### **Education Level**

According to Table 2, the sample size at the education level is as follows: Pre-school (0.429), Elementary (2.924), Junior High School (1.09), Senior High School (0.942), and University (1.172). Heterogeneity tests yielded  $Q$ -value = 32.466 and  $p > 0.05$ , indicating that the application of Jigsaw learning to mathematical abilities was influential at all stages of schooling, from pre-primary to university.

### **Sample Size**

Based on Table 2. It was shown that a sample size with a group of 30 or less had an effect size of 0.114, while a sample size with a group of 31 or more had an effect size of 1.384. Based on the heterogeneity test,  $Q$ -value = 12.005 and  $p < 0.05$ . In this situation, it suggests that the sample size influences Jigsaw technique learning with students' mathematical skills.

### **Publication Source**

According to the publication source, the effect size of journal research was 0.178, whereas the effect size of proceedings research was 2.26. Judging from the heterogeneity of  $Q$ -value = 19.84 and  $p < 0.05$ , the entire paper shows that Jigsaw learning affects students' mathematical abilities.

### **Discussion**

Essentially, the purpose of this study is to determine whether the Jigsaw approach has a significant impact on students' mathematical abilities. Based on the analysis, an effect size of 1,146 was obtained, which shows that this study has a considerable influence. In accordance with the research that has been conducted, there is a possibility that students can contribute to solving problems in group discussions using the Jigsaw learning model, due to its significant influence (Tamur et al., 2021).

The number of subjects studied in this study was 1252 with an average of 69 people. In this case, the effect size of 1,146 shows that the Jigsaw method affects mathematical ability (Cohen et al., 2018). In line with other studies, learning using the Jigsaw method is more fun than ordinary learning because students can find information from other groups (Wardani, 2015). Next, researchers conducted an analysis based on categorical variables. It can be seen that the amount of the influence in this study is clarified beginning with the level of education, country, sample size, and publication source.

Analysis of country categories found that research in Indonesia and abroad showed no influence between the Jigsaw learning model on mathematical ability. In this study, the number of samples from 30 papers is comparable. This means that in addition to Indonesia, abroad this research has been carried out a lot even not a few who use modifications to the variables studied with the main variable being Jigsaw learning. For example, research (Abed et al., 2020) that predicts Jigsaw-type learning strategies on students' mathematics learning achievement. Furthermore, other data show that the Jigsaw technique of learning geometric information is more effective than the lecture method (Timayi et al., 2015). Another study related to Jigsaw learning in Turkey states that there is an influence on students' abilities in natural science laboratory practice (Karacop, 2017).

Next, analyze category variables related to education level. Judging from the comparison of the magnitude of the effect size between Pre-School: Elementary: Junior High: High School: University (0.429: 2.924: 1.09: 0.942: 1.172) the results show that learning the Jigsaw method has a major effect on the elementary level. The findings also show that learning mathematics using the Jigsaw method is more effective at the elementary level than at other levels. According to research (Sulistiyowati & Astuti, 2020), the Jigsaw method of learning has a high level of cooperation as indicated by post-test and pre-test findings. Although this is a contradiction where learning mathematics using the Jigsaw method at the high school level affects students' mathematical

communication skills (Yeubun et al., 2020).

Learning mathematics using the Jigsaw method, as shown in Table 2, also demonstrates that many research samples were collected at the secondary school level. This happens because the level of thinking has entered the formal stage. On the other hand, this learning triggers the psychology of students to be curious about their peers (Utami et al., 2021). In addition to their mathematical abilities, students' mathematical successes have beneficial consequences after the Jigsaw learning approach is implemented (Ribut, 2021). However, other studies on cooperative learning with the type of Think Pair Share aided by comics show that it is no better than not using comics to develop problem-solving skills (Turyanto et al., 2019). However, Pair Check cooperative learning has been shown to improve students' overall cooperative abilities (Wijayanti & Kusdiyanta, 2019).

In this study, sample size was also applied to categorical variables to clarify the size of the effect on the study. The findings showed that (31 or more) had a greater influence than other categories. This study also conducted an analysis of publication sources on categorical variables. Based on the findings, 1 literature was obtained from proceedings and 29 other literature was obtained from journals. These data imply that the study was free of publication bias, which is supported by trim and fill.

Many studies are not taken or do not fall into the required category while examining this research. Such research conducted by (Budiawan & Arsani, 2013) using the same variables but carried out on sports subjects. In addition, there are also some unqualified studies where there is a lack of pretest data as a control study. Of the 500 data collected, only about 30 studies were included in the requirements after several screenings. And obviously, it does not end there; this study needs to be researched further to determine its effectiveness.

## CONCLUSION

This research was conducted by taking articles from proceedings and international journals in the range of 2010 – 2023. A meta-analysis research with 30 samples revealed a fixed effect with an effect size of 1,146, indicating that mastering the Jigsaw technique had a significant impact on students' mathematical abilities. This means that Jigsaw learning is still relevant to improve students' mathematical skills. Furthermore, this study was conducted analysis based on category variables divided into four variables. Based on the analysis of education levels, it was discovered that the degree of the influence varied depending on the study. However, learning using the Jigsaw method is more influential at the elementary level than other levels. In addition, the number of samples in 31 or more has a higher effectiveness and also publication sources based on journals have more significant influence, while analysis in countries does not have an influence on both research from Indonesia and abroad.

In the world of education, the application of the Jigsaw method is quite effective, as evidenced by the findings of several studies, particularly at the elementary level, where students enjoy playing and learning in groups, exchanging information, and working together to find information. This research has limitations because the sample in this study was obtained from Google Scholar using PoP software which means there are still many other research samples that were not carried out because of access or paid constraints. Further research requires good collaboration to review more deeply about this research.

## CONFLICT OF INTEREST

## ACKNOWLEDGEMENT

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**4. Bukti konfirmasi review dan hasil review  
kedua  
(30 Januari 2024)**

4/11/25, 10:53 PM [Formatif] Editor Decision - joko\_soebagyo@uhamka.ac.id - Universitas Muhammadiyah Prof. Dr. Hamka Mail

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Ari Irawan, M.Pd <pengembangjurnalunindra@gmail.com>  
to me, Samsul, Huri, Leonard

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We have reached a decision regarding your submission to **Formatif: Jurnal Ilmiah Pendidikan MIPA**, "Is the Jigsaw Method Still Relevant for Improving Mathematical Ability? Meta-Analysis Studies".

Our decision is to: Revision Required  
Silakan direvisi sesuai dengan masukan reviewer dan kami tunggu paling lambat tanggal 7 Februari 2024. terima kasih

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to M.Pd

ok, i will revise as soon as possible  
thanks

Hasil Reviewer A

Is the Jigsaw Method Still Relevant for Improving Mathematical Ability?  
Meta-Analysis Studies

Author 1, Author 2, Author 3, Author 4

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Abstract

Based on the findings of research that has been done, learning the Jigsaw method also has an influence on the mathematical ability of students but some do not have a significant influence. As a result, meta-analysis research is required to provide thorough and in-depth conclusions about the Jigsaw method's applicability to students' mathematical abilities. Comprehensive Meta-Analysis is used to evaluate property values based on comparisons with similar properties in the same area. Data obtained from Publish or Perish with a year level from 2010 to 2023 there are a total of 501 articles with a Google Scholar data base. The total number of eligible journals and will be analyzed is 30 samples with a total of 1252 subjects. The moderator variables in this study consider the country, education level, sample size and publication source. According to the study's findings, the Jigsaw technique had a significant impact on arithmetic ability (P-value 0.05), with an effect size of 1.146 classed as extremely high based on a fixed effect and an error standard of 0.045. The results showed that the Jigsaw method is still relevant to improve students' mathematical skills, especially at the elementary school level. In contrast, The meta-analysis revealed that the Jigsaw method had no effect on pupils' mathematical abilities across country categories.

Keywords: Jigsaw methods, mathematical abilities, meta-analysis

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INTRODUCTION

Recognize mathematics as an abstract science that is the basis for achieving other sciences. Mathematics complements all existing sciences ranging from science, technology, art and many others (Kamarullah, 2017). The level of difficulty in mathematics is often used as a benchmark in achieving success. No wonder many of the nation's students are required to be proficient in mathematics. Sometimes the difficulty in solving abstract problems often makes interest in learning decrease so that you are lazy to learn, this is a trigger factor for problems in learning (Siswono, 2014). In mathematics, mathematical ability is not only measured on one ability. Mathematical abilities are grouped into five understandings ranging from mathematical understanding, problem solving, reasoning, connection and communication (Sumarmo, 2012). Mathematics learning must instill rational thinking processes with the laws of mathematical logic to develop thinking processes in solving mathematical problems (Maarif et al., 2018). In understanding logic, of course, requires motivation and good learning and teaching. Not all teaching provided is able to make some students interested in learning. Therefore, as a good teacher, there needs to be variety in providing learning models. This variant is used to ensure the learners grasp the topic and that objectives for learning are achieved. Currently, there are many learning models that are often found, ranging from Problem Based Learning (PBL), Project Based Learning (PjBL), Realistic Mathematics Education (RME), to Cooperative Learning (CL). The development of technology, a lot of research related to learning. In fact, not a few studies that vary learning with other methods.

Cooperative learning was first studied in 1898 by Roger and Johnson in about 600 experiments. Cooperative learning is learning that creates interaction between group members and teachers try to condition it by motivating students to always develop a sense of mutual need in a team

Commented [A1]: Apakah benar? Cek kembali.

Commented [A2]: database

Commented [A3]: Maksudnya apa?

Commented [A4]: Misinterpretasi

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(Jaelani, 2015). Social behavior learning is specifically developed to assist students in collaborating while learning. Cooperative learning is a learning paradigm in which students participate and interact with one another in small groups of four to six persons (Saputra et al., 2017). There are various variations of models that can be used in cooperative learning, namely (1) STAD, (2) Group Investigation, (3) Jigsaw, (4) Think-Pair-Share, (5) Inside-Outside Circle, (6) Make a Match, (7) Listening Team, (8) The Power of Two, and (9) Bamboo Dancing.

Jigsaw is one of the models of cooperative learning. Jigsaw type learning is learning in a learning group where there is interaction between each group member and has responsibility for the material in the group and the ability to master and teach the topic to the other members of the group (Lubis & Harahap, 2016). The initial group and the expert group are displayed in the puzzle cooperative learning paradigm. The origin group, or parent group of students, consists of students from different racial, ethnic, and socioeconomic backgrounds. While the expert group consists of members of different origin groups and is tasked with researching and studying certain subjects while carrying out tasks that will be communicated to members of the origin group. A number of specialists from the initial group have been combined to form the expert group. Being interconnected with each other where each student is able to convey the information needed to their teammates so that the goal in solving problems can be achieved is the key to the success of Jigsaw (Werdiningsih & Mukhlisin, 2021). In this learning students work in a team and are assigned to read and study a subject. Random selection is made for each member of the group who is designated as an expert in a particular field. Furthermore, the experts reported to the group and met with other groups to discuss the material learned then returned to their group to teach the material to their teammates (Widyastuti, 2015). The characteristic of the Jigsaw type that distinguishes it from other types of cooperatives is that there are study groups and specialist groups (Hibattulloh & Sofyan, 2014).

One of the learning models that can promote student activity, involvement, and knowledge of the material is cooperative learning. The Jigsaw cooperative learning model is one example (Nurfutriyanti, 2017). This learning model is possible to be applied to young children, because this type of children is also divided into several heterogeneous groups according to ability and gender, so that group characters are formed into parallels (Poerwati et al., 2020). The Jigsaw cooperative paradigm is intended to improve students' problem-solving and critical thinking abilities because in discussion activities students are grouped into specialist groups and origin teams to solve mathematical problems (Handayani, 2020).

In understanding abstract science, the ability to train critical thinking needs to be taught to students (Sarman & Soebagyo, 2022). Critical thinking is the ability of human thinking that has systematic and logical steps (Saviraningrum & Soebagyo, 2022). Thinking logically means being precise, which is an important skill for life and work to work effectively in all areas of life. The advantage in critical thinking, we can assess the level of thoroughness or truth of the question and without any information it is not easy to express what we want to convey (Zuhasni, 2022). In addition, mathematical creative thinking skills, namely the ability to think based on data and information, are available to find possible answers to such problems from different points of view on problems in each individual where it is more emphasized the suitability of answers and the versatility of answers (Yayuk et al., 2020). That is, creative thinking skills should belong to everyone (Florentina & Leonard, 2017). No less important, to find relationships from a representation of concepts and procedures, to grasp between mathematical themes and apply mathematical concepts in other fields or daily life, the capacity to make mathematical connections is required (Widarti, 2013).

The Jigsaw method of learning, which is derived from research findings, assists students in understanding the findings they make (Sari & Fitriani, 2018). In other studies there is an influence on the mathematical ability of students but there are also those that do not have a significant influence. Of course, in various studies there are different kinds of conclusions even though the variables studied have similarities. Based on the existing problems, Meta-analysts can provide comprehensive and in-depth conclusions on certain variables or topics that want to be discussed. This study can answer how much influence the Jigsaw method has based on the desired category variables. One of the results of this study is a significant improvement in students' mathematical abilities after attending the Jigsaw method lecture with discussion assessment and based only on the findings of the preliminary and final tests (Edriati et al., 2015).

**Commented [A6]:** cek komentar selanjutnya tentang konsistensi penulisan

**Commented [A7]:** akronim ini sebaiknya dijelaskan dahulu sebelum digunakan selanjutnya.

**Commented [A8]:** Mengapa dipilih model pembelajaran Jigsaw, bukan lainnya?

**Commented [A9]:** Metode atau model pembelajaran? Sebutkan secara konsisten.

**Commented [A10]:** Cek penulisan

**Commented [A11]:** Kalimat ini ambigu, penelitian ini yang dimaksud apakah penelitian ini atau penelitian Edriati? Apakah meta-analisis pada model pembelajaran jigsaw belum pernah dilakukan sebelumnya? Jika ada sebutkan, dan letak perbedaan dengan penelitian ini dimana?

## METHODS

This study focuses on quantitative data research analysis based on Google Scholar database sources, specifically to investigate **Jigsaw models** with **math ability**. The purpose of this analysis was to identify the magnitude of the influence on the Jigsaw learning **method** and to investigate the impact of characteristics on mathematical ability in determining the variation in effect size of each available research. Analysis using a meta-analysis approach is used to achieve this purpose. Meta-analysis is used to compare primary study with other scientific advancements in the form of drawing statistical findings in the form of effect size on quantitative data studies based on relevant themes (Rosdiana, 2021). The steps in compiling the meta-analysis, starting from; (1) choose the criteria for the article to be researched, (2) look for literature sources related to relevant research to be used, (3) code the article to be used, (4) conduct analysis and classification, (5) interpret findings based on the article under study (Sukmawati, 2020).

### Literary Search

This research uses the Google Scholar database as a location for document search. Furthermore, the use of Publish or Perish is applied as a reference in downloading studies related to the application of the Jigsaw method by combining keywords into Jigsaw, **math ability** (Eryanti & Soebagyo, 2021; Haniyah & Soebagyo, 2021; Sarman & Soebagyo, 2022). Seen in Figure 1, it is obtained that the search process for the application of the Jigsaw method on Google Scholar using the **PoP** application reaches 500 data.

Cites	Per year	Rank	Authors	Title	Year	Publication	Publisher	Type
42	9	3.80	1 N Rambe, E Syah...	The Effect of the Jigsaw Cooperative...	2020	Research and Critic in...	pubs.ceramicscholar.org	PDF
41	5.86	2	I Dewi, MS Hidayat...	... of Geometric Teaching Materials...	2016	Journal of Education and ...	ERIC	
34	2.80	3	S Sumarsi, D Darhi...	The students' mathematical conc...	2018	Journal of Physics ...	scipience.sip.org	
34	6.80	4	OP Sari, E Syahput...	An analysis of spatial ability and s...	2018	American ...	article.ascelibrary.org	PDF
22	2.75	5	S Edrati, Y Anggoro...	Efektifitas Model Jigsaw Diarter...	2015	Jurnal Cakrawala Pendidikan...	jurnal.uny.ac.id	
23	6.25	7	E Ertan, E Kartem...	Mathematical creative thinking a...	2020	Unnes Journal of Mathem...	journal.unnes.ac.id	
23	6.25	7	E Ertan, E Kartem...	Understanding Ability of Mathem...	2019	Journal of Primary Educat...	journal.unnes.ac.id	
8	4.00	9	H Sa'adah, S Syaf...	Student team achievement divisi...	2021	Desimal: Jurnal ...	ejournal.negeritanan.ac.id	
46	5.75	10	S Mawardi, A Riy...	The discrepancy of students' mat...	2015	International Journal of ...	ijgm.com	
1	0.20	11	DR Satri, E Surya...	Differences Ability of Problem Sol...	2018	3rd Annual International ...	atlantis-press.com	PDF
19	2.11	12	K Aini, M Mham...	Meningkatkan Kemampuan Pem...	2014	Jurnal Didakta Matematika	jurnal.unyoh.ac.id	
21	2.33	13	C Young, E Carlin...	Gestures and speech input are inte...	2014	Proceedings of the ...	scisearch.org	PDF
40	3.45	14	C Christie, C Buha...	The jigsaw technique and self eff...	2012	European journal of psych...	Springer	
44	11.00	15	R Fanan, C Makom...	Visual and spatial working memo...	2019	Frontiers in Psychology	frontiersin.org	HTML
14	2.33	16	M Juliana, E Surya	An Analysis Of Jigsaw Cooperative...	2017	OP Advance Research A...	researchgate.net	PDF
4	0.80	17	AA Satriyati, H Ma...	THE DIFFERENCE OF STUDENT...	2018	Journal of Mathematics	ojs.ia.ac.id	PDF
5	1.00	18	AA Satriyati, H Ma...	... OF STUDENTS ACHIEVEMENT L...	2018	Infinity Journal	e-journal.digipolihwang.ac...	

Figure 16. Google Scholar database search results (Jigsaw, Math ability)

### Literary Inclusion Criteria

Throughout the present investigation, the research that was successfully found using the **PoP** software was then collated based on the requirements listed following: (1) write keywords using English settings, then retrieve the Google Scholar database at a vulnerable time between **2010-2023**, (2) statistical information is used to obtain the effect size value. And journals or study criteria that do not match will be removed from the analysis data, and (3) learning to use a quantitative approach where in quantitative data there must be control groups and experiments. Journals or papers with just a single sample and a qualitative approach will be excluded from the data analysis.

The data screening in this investigation was done using the **PRISMA** protocols shown in Figure 2.

**Commented [A12]:** Cek komentar sebelumnya

**Commented [A13]:** Tambahkan kata hubung antara dua kata kunci yang digunakan dalam pencarian.

**Commented [A14]:** Jelaskan dahulu akronim ini, sebelum digunakan selanjutnya.

**Commented [A15]:** Mengapa dipilih rentang tahun ini?

**Commented [A16]:** Jelaskan akronim ini terlebih dahulu, sebelum digunakan selanjutnya.

**Commented [A17]:** 1 paragraf sebaiknya lebih dari 1 kalimat.



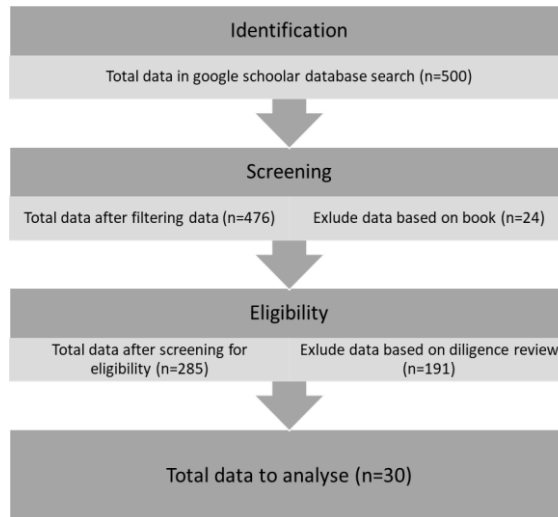


Figure 17. Filter data using PRISMA

## Coding

All studies that match the criteria are coded manually using a detailed coding scheme based on protocols. In this study, the instrument was carried out using the provision of codes (*categories*). Coding is done to separate individual data information into numerical data. A random sample of 5 valid studies was reproduced and divided among coders to determine reliability. The coder is given a copy of the article, as well as the coding form and protocol. To assess the reliability of these coders, the following formula is employed to calculate percent agreement (PA):

$$PA = \frac{N_A}{N_A + N_P} \times 100\%$$

In this scenario,  $N_A$  represents the total number of agreements, while  $N_P$  represents the entire number of disagreements.

## Statistical Analysis

The data was evaluated with the CMA application, with special attention paid to the effect size, which is defined as the influence of the Jigsaw approach on students' mathematical skills. The Comprehensive Meta-Analysis is beneficial for adjusting the effect size of research, including the overall effect size, P-value, Q-statistic, and truth interval. In addition, the program creates research forest plots and funnel plots. The g Hedges measure was utilized in this analysis, and the size effect was classified as less than 0.2 (negligible), 0.2 to 0.5 (small effect), 0.5 to 0.8 (moderate effect), 0.8 to 1.3 (big effect), and more than 1.3 (very large effect) (Cohen et al., 2007). The random effect technique was chosen as the estimation method since there is no assumption that all research have the same effect. The randomized effect model in this study was selected after a successful heterogeneity test. The p value is used to perform this test. If the p-value is less than 0.05, all studies will be identical, and the null hypothesis and homogeneity will be rejected. The rejection of the null hypothesis suggests that population parameters may not be measured with the same effect size across studies or study groups (Retnawati et al., 2018). There is evidence that different study categories have different effects on study effect sizes.

To avoid misrepresentation of results, publication bias is checked. Publication bias is the likelihood that studies appearing in published literature are considered statistically significant to be published (Cooper et al., 2009). In anticipation, a bias analysis was carried out on the funnel plot to see if the research was free from bias. When the distribution of impact sizes on vertical lines was symmetrical, publication bias was judged strong in this study. However, if the size distribution of the effect is not perfectly symmetrical, it is necessary to use the trim and fill method. If the observed

**Commented [A18]:** Identifikasi sesuaikan yang ada di hasil.  
Jelaskan tahap screening sesuai dengan penjelasan pada hasil khususnya "Literature Selection Results".

**Commented [A19]:** Maksud kalimat ini apa?

**Commented [A20]:** Siapa pengodanya? Berapa orang pengode? Hal ini akan berpengaruh pada penggunaan kata tunggal atau jamak.

Bagaimana cara kerja pengode? Jelaskan juga hubungan antar pengode, independent atau dependen?

**Commented [A21]:** percentage

**Commented [A22]:** 1 paragraf sebaiknya lebih dari 1 kalimat.

**Commented [A23]:** Sebutkan penjelasan akronim ini dulu, sebelum akronim digunakan lebih lanjut.

**Commented [A24]:** Gunakan istilah yang baku, misal confidence interval

**Commented [A25]:** Overlapping dalam pengategorian. Sebaiknya gunakan interval berupa notasi matematika.

**Commented [A26]:** Cek komentar sebelumnya

effects and virtual effects generated by randomized effects models are found to be similar, then the study is immune to publication bias.

## RESULTS & DISCUSSION

### Results

#### Literature Search Results

The goal of this study was to determine whether the magnitude of the effect created had an effect on learning the Jigsaw method and mathematical competence based on category variables. Therefore, researchers try to search literature using PoP (Publish or Perish) software by applying several criteria. The first criterion, researchers use vulnerable research time in 2010 – 2023. Furthermore, the second criterion of researchers used the keywords Jigsaw and Math ability, and the maximum number of results was limited to 500 data. From the topics used, 501 articles were collected, with 24 data coming from books and the rest coming from journals, citations and documents.

**Commented [A27]:** Penjelasan ini sebaiknya disebutkan di bagian awal artikel yang menyebutkan hal ini. Selanjutnya cukup menggunakan akronim saja.

**Commented [A28]:** Dibatasi 500 dokumen

**Commented [A29]:** Tapi mengapa diperoleh 501?

**Commented [A30]:** Sebarannya bagaimana?

#### Literature Selection Results

After setting criteria for literature search, the researcher converts the data into excel and eliminates the data in the appropriate journal. First, researchers filter data that is included in journals or articles. Second, researchers use a quantitative approach to collect data that has an experimental class and a control class. Third, researchers collect statistical data such as the number of samples, average values and standard deviations. This statistical data aims to calculate the size of the effect to be studied. Furthermore, screening through the PRISMA method is carried out to ensure the accuracy of the data obtained. Not only that, but researchers must guarantee that the journal's title and theme are consistent with the criteria variables.

**Commented [A31]:** Journal atau prosiding conference?

**Commented [A32]:** Gunakan istilah yang tepat, misal sample size

**Commented [A33]:** Gunakan istilah yang tepat, misal mean. Kata value dihapus saja. Kemudian di antara mean dan standard deviations diberi tanda pemisah koma (,).

#### Results Criteria

The results of the criteria in this study focused on vulnerable years 2010 - 2023. The selection of criteria on this year's vulnerability was carried out to ensure that the available research is up-to-date. From the results of the criteria that have been filtered, researchers consider choosing research sourced from journals and proceedings. In addition, researchers also obtained various journals from various countries with the same topic, ranging from Asian to European countries. Furthermore, researchers consider the degree of education beginning with (pre-school, elementary, junior high, high school, and university). The many variations that have been studied at this level of education add to the accuracy of a study. Furthermore, researchers also looked at the number of sample sizes in a study and paid attention to whether each of these journals had a control class and an experimental class. The selected research is also equipped with post-test and pre-test data, average values and standard deviations to see the extent of the data spread and whether there are data deviations in the average value.

**Commented [A34]:** mean

**Commented [A35]:** hapus

**Commented [A36]:** mean

**Commented [A37]:** hapus

#### Statistical Analysis Results

The results of the study here aim to answer the research question. Figure 3 depicts the findings of a meta-analysis of 30 filtered and collected data from Google Scholar. Figure 3 contains the identification of the names of the studies. Furthermore, the magnitude of the effect is shown which contains the results of the intervention. It can be seen that there is 1 data that is less than 0 or under consideration, while the average confidence interval that stretches horizontally or is more than 0 is on the right. This means that the effects of the intervention are beneficial. In addition, figure 3 also shows the heterogeneity of a data to see discrepancies in the source of findings from the study.

**Commented [A38]:** Figure

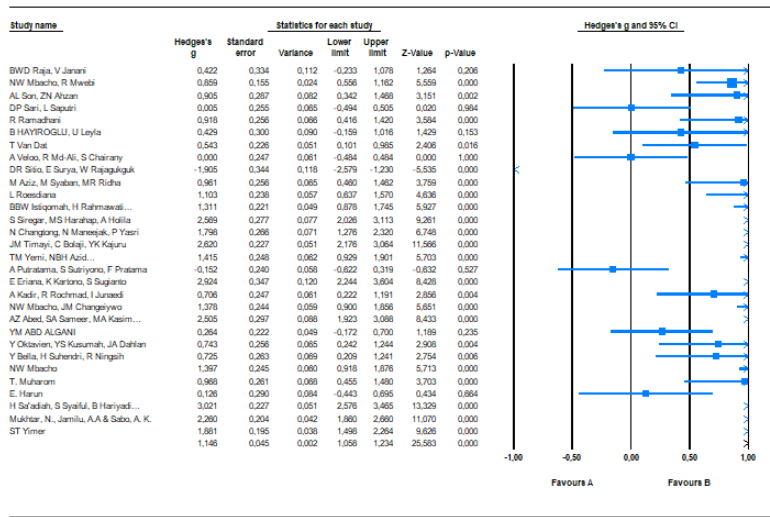


Figure 18. Research Forest Plot

According to Figure 3, there is an inconsistent response rate. It is clear that the research is likely to be diverse. As a result, it must be statistically examined such that the starting assumptions are consistent with the estimation approach.

Table 7. Meta Results - Analysis according to the Estimation method

Model	N	Hedge's g	Standard error	Test of null		Q	P	Decision
				Z-value	P-value			
Fixed-effects	30	1.146	0.045	25.583	0.000	447.062	0.000	Reject
Random-effects	30	1.095	0.177	6.189	0.000			

Table 1 displays the findings of a meta-analysis of 30 papers from conferences and international journals. Table 1 shows that the P value is 0.05, indicating that each study has a diverse impact size. Therefore, a fixed effect model with a very high effect size of 1.146 was used. Using a null test obtained P less than 0.05 with a fixed effects model. In addition, a z value of 25,583 was obtained indicating that the research results were significant for  $P < 0.05$  (Musna et al., 2021). To put it another way, the Jigsaw-type learning model has a big impact on mathematical ability.

**Commented [A39]:** Sebaiknya bagian ini masuk dalam kategori gambar, karena tidak bisa diedit, kecuali penulis menggantinya dalam format tabel. Judul kolom 4 tidak terlihat jelas.

**Commented [A40]:** Apakah yakin international journal jika mengambil melalui database GS? Perlu pengecekan kembali sumber terpilih agar dapat diyakini berasal dari konferensi atau jurnal internasional.

**Commented [A41]:** effect

**Commented [A42]:** Gunakan symbol titik (.) untuk menunjukkan desimal

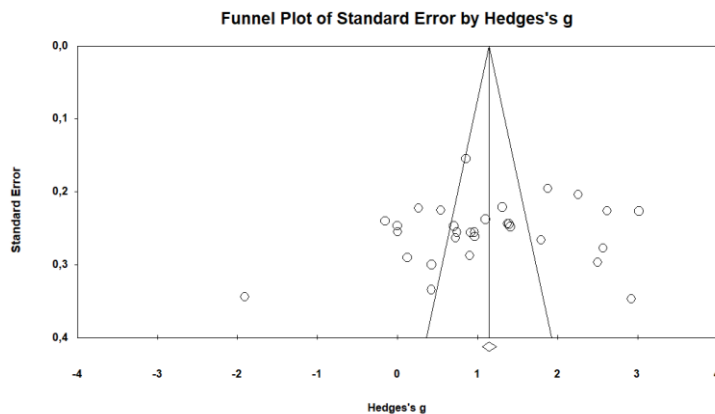


Figure 19. Funnel plot of 30 samples

Then, as shown in Figure 5, we will show a funnel plot with the research spread out and not symmetrical in the funnel, requiring trim and fill to check whether there is a difference with the influence of publication bias.

#### Duval and Tweedie's trim and fill

	Studies Trimmed	Fixed Effects			Random Effects			Q Value
		Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit	
Observed values		1,14597	1,05817	1,23376	1,09469	0,74799	1,44139	447,06230
Adjusted values	0	1,14597	1,05817	1,23376	1,09469	0,74799	1,44139	447,06230

Figure 20. Trim and Fill

The findings of trim and fill indicate that there is no difference or opposite according to the fixed effect model, so no research or study is trimmed or added to this study. The overall effect size is 1.14597 rounded up to 1.146 is a very high value for an effect size.

Furthermore, in addressing the following question, it is demonstrated that the estimation approach, as previously stated, matches the fixed effect model. This shows that the effect sizes of each study are varied, necessitating a detailed examination of the categorical factors influencing the association between the Jigsaw learning model and mathematical competence. As a result, Table 2 shows the summary results of the category variable analysis.

Table 8. Summary of Category Variable Analysis

No	Category Variable	Group	N	Combined Effect Size (Hedge's g)	Test of null (2-Tail)		Between-Classes Effect (Q-value)	Df (Q)	P-value	Decision
					Z	P-value				
1	Country	Indonesia	15	0.99	3.439	0.001	0.331	1	0.565	Reject $H_0$
		Overseas	15	1.199	5.412	0				
		University	4	1.172	3.797	0				
2	Educational level	High School	9	0.942	3.672	0	32.466	4	0	Reject $H_0$
		Primary School	15	1.09	3.702	0.000				
		Elementary	1	2.924	8.428	0.000				
		Pre School	1	0.429	1.429	0.153				
3	Sample Size	30 or less	7	0.114	0.361	0.000	12.005	1	0.001	Reject $H_0$
		31 or more	23	1.384	7.51	0.000				
4	Publication Source	Journal	29	0.178	5.919	0.000	19.84	1	0	Reject $H_0$
		Proceding	1	2.26	11.07	0.000				

Commented [A43]: Semua gambar dirujuk dalam naskah.

Commented [A44]: Cek penomoran gambar, sepertinya salah. 1 paragraf sebaiknya lebih dari 1 kalimat.

Commented [A45]: Rujuk gambarnya.

Commented [A46]: hapus

Commented [A47]: research question

Commented [A48]: Decision 1, menggunakan istilah yang tidak wajar. Dalam statistika yang diuji adalah  $H_0$ , jadi yang diterima atau ditolak adalah  $H_0$ . Dalam berbagai referensi digunakan istilah "not reject  $H_0$ ".

Variabel terahir terjadi kesalahan penulisan.

Sebaiknya bagian ini masuk dalam kategori gambar, karena tidak bisa diedit, kecuali penulis menggantinya dalam format tabel.

Penulisan desimal juga harus konsisten, misal tiga angka di belakang koma.

## Country

The effect size in Indonesian study was 3,439, whereas the effect size in international research was 5,412. According to the heterogeneity of  $Q$ -value = 0.331 and  $p > 0.05$ , studies on the Jigsaw learning model conducted in Indonesia and abroad have no impact on students' mathematical abilities.

## Education Level

According to Table 2, the sample size at the education level is as follows: Pre-school (0.429), Elementary (2.924), Junior High School (1.09), Senior High School (0.942), and University (1.172). Heterogeneity tests yielded  $Q$ -value = 32.466 and  $p > 0.05$ , indicating that the application of Jigsaw learning to mathematical abilities was influential at all stages of schooling, from pre-primary to university.

## Sample Size

Based on Table 2. It was shown that a sample size with a group of 30 or less had an effect size of 0.114, while a sample size with a group of 31 or more had an effect size of 1.384. Based on the heterogeneity test,  $Q$ -value = 12.005 and  $p < 0.05$ . In this situation, it suggests that the sample size influences Jigsaw technique learning with students' mathematical skills.

## Publication Source

According to the publication source, the effect size of journal research was 0.178, whereas the effect size of proceedings research was 2.26. Judging from the heterogeneity of  $Q$ -value = 19.84 and  $p < 0.05$ , the entire paper shows that Jigsaw learning affects students' mathematical abilities.

## Discussion

Essentially, the purpose of this study is to determine whether the Jigsaw approach has a significant impact on students' mathematical abilities. Based on the analysis, an effect size of 1,146 was obtained, which shows that this study has a considerable influence. In accordance with the research that has been conducted, there is a possibility that students can contribute to solving problems in group discussions using the Jigsaw learning model, due to its significant influence (Tamur et al., 2021).

The number of subjects studied in this study was 1252 with an average of 69 people. In this case, the effect size of 1,146 shows that the Jigsaw method affects mathematical ability (Cohen et al., 2018). In line with other studies, learning using the Jigsaw method is more fun than ordinary learning because students can find information from other groups (Wardani, 2015). Next, researchers conducted an analysis based on categorical variables. It can be seen that the amount of the influence in this study is clarified beginning with the level of education, country, sample size, and publication source.

Analysis of country categories found that research in Indonesia and abroad showed no influence between the Jigsaw learning model on mathematical ability. In this study, the number of samples from 30 papers is comparable. This means that in addition to Indonesia, abroad this research has been carried out a lot even not a few who use modifications to the variables studied with the main variable being Jigsaw learning. For example, research (Abed et al., 2020) that predicts Jigsaw-type learning strategies on students' mathematics learning achievement. Furthermore, other data show that the Jigsaw technique of learning geometric information is more effective than the lecture method (Timayi et al., 2015). Another study related to Jigsaw learning in Turkey states that there is an influence on students' abilities in natural science laboratory practice (Karacop, 2017).

Next, analyze category variables related to education level. Judging from the comparison of the magnitude of the effect size between Pre-School: Elementary: Junior High: High School: University (0.429: 2.924: 1.09: 0.942: 1.172) the results show that learning the Jigsaw method has a major effect on the elementary level. The findings also show that learning mathematics using the Jigsaw method is more effective at the elementary level than at other levels. According to research (Sulistiyowati & Astuti, 2020), the Jigsaw method of learning has a high level of cooperation as indicated by post-test and pre-test findings. Although this is a contradiction where learning mathematics using the Jigsaw method at the high school level affects students' mathematical

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communication skills (Yeubun et al., 2020).

Learning mathematics using the Jigsaw method, as shown in Table 2, also demonstrates that many research samples were collected at the secondary school level. This happens because the level of thinking has entered the formal stage. On the other hand, this learning triggers the psychology of students to be curious about their peers (Utami et al., 2021). In addition to their mathematical abilities, students' mathematical successes have beneficial consequences after the Jigsaw learning approach is implemented (Ribut, 2021). However, other studies on cooperative learning with the type of Think Pair Share aided by comics show that it is no better than not using comics to develop problem-solving skills (Turyanto et al., 2019). However, Pair Check cooperative learning has been shown to improve students' overall cooperative abilities (Wijayanti & Kusdiyanta, 2019).

In this study, sample size was also applied to categorical variables to clarify the size of the effect on the study. The findings showed that (31 or more) had a greater influence than other categories. This study also conducted an analysis of publication sources on categorical variables. Based on the findings, 1 literature was obtained from proceedings and 29 other literature was obtained from journals. These data imply that the study was free of publication bias, which is supported by trim and fill.

Many studies are not taken or do not fall into the required category while examining this research. Such research conducted by (Budiawan & Arsani, 2013) using the same variables but carried out on sports subjects. In addition, there are also some unqualified studies where there is a lack of pretest data as a control study. Of the 500 data collected, only about 30 studies were included in the requirements after several screenings. And obviously, it does not end there; this study needs to be researched further to determine its effectiveness.

## CONCLUSION

This research was conducted by taking articles from proceedings and international journals in the range of 2010 – 2023. A meta-analysis research with 30 samples revealed a fixed effect with an effect size of 1.146, indicating that mastering the Jigsaw technique had a significant impact on students' mathematical abilities. This means that Jigsaw learning is still relevant to improve students' mathematical skills. Furthermore, this study was conducted analysis based on category variables divided into four variables. Based on the analysis of education levels, it was discovered that the degree of the influence varied depending on the study. However, learning using the Jigsaw method is more influential at the elementary level than other levels. In addition, the number of samples in 31 or more has a higher effectiveness and also publication sources based on journals have more significant influence, while analysis in countries does not have an influence on both research from Indonesia and abroad.

In the world of education, the application of the Jigsaw method is quite effective, as evidenced by the findings of several studies, particularly at the elementary level, where students enjoy playing and learning in groups, exchanging information, and working together to find information. This research has limitations because the sample in this study was obtained from Google Scholar using PoP software which means there are still many other research samples that were not carried out because of access or paid constraints. Further research requires good collaboration to review more deeply about this research.

## CONFLICT OF INTEREST

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Hasil Reviewer B

## Is the Jigsaw Method Still Relevant for Improving Mathematical Ability? Meta-Analysis Studies

Author 1, Author 2, Author 3, Author 4

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### Abstract

Based on the findings of research that has been done, learning the Jigsaw method also has an influence on the mathematical ability of students but some do not have a significant influence. As a result, meta-analysis research is required to provide thorough and in-depth conclusions about the Jigsaw method's applicability to students' mathematical abilities. Comprehensive Meta-Analysis is used to evaluate property values based on comparisons with similar properties in the same area. Data obtained from Publish or Perish with a year level from 2010 to 2023 there are a total of 501 articles with a Google Scholar data base. The total number of eligible journals and will be analyzed is 30 samples with a total of 1252 subjects. The moderator variables in this study consider the country, education level, sample size and publication source. According to the study's findings, the Jigsaw technique had a significant impact on arithmetic ability (P-value 0.05), with an effect size of 1.146 classed as extremely high based on a fixed effect and an error standard of 0.045. The results showed that the Jigsaw method is still relevant to improve students' mathematical skills, especially at the elementary school level. In contrast, The meta-analysis revealed that the Jigsaw method had no effect on pupils' mathematical abilities across country categories.

**Keywords:** Jigsaw methods, mathematical abilities, meta-analysis

(\*) Corresponding Author:

**How to Cite:** XXXXXX. (2018). XXXX. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, XX (x): x-xx.

## INTRODUCTION

Recognize mathematics as an abstract science that is the basis for achieving other sciences. Mathematics complements all existing sciences ranging from science, technology, art and many others (Kamarullah, 2017). The level of difficulty in mathematics is often used as a benchmark in achieving success. No wonder many of the nation's students are required to be proficient in mathematics. Sometimes the difficulty in solving abstract problems often makes interest in learning decrease so that you are lazy to learn, this is a trigger factor for problems in learning (Siswono, 2014). In mathematics, mathematical ability is not only measured on one ability. Mathematical abilities are grouped into five understandings ranging from mathematical understanding, problem solving, reasoning, connection and communication (Sumarmo, 2012). Mathematics learning must instill rational thinking processes with the laws of mathematical logic to develop thinking processes in solving mathematical problems (Maarif et al., 2018). In understanding logic, of course, requires motivation and good learning and teaching. Not all teaching provided is able to make some students interested in learning. Therefore, as a good teacher, there needs to be variety in providing learning models. This variant is used to ensure the learners grasp the topic and that objectives for learning are achieved. Currently, there are many learning models that are often found, ranging from Problem Based Learning (PBL), Project Based Learning (PJBL), Realistic Mathematics Education (RME), to Cooperative Learning (CL). The development of technology, a lot of research related to learning. In fact, not a few studies that vary learning with other methods.

Cooperative learning was first studied in 1898 by Roger and Johnson in about 600 experiments. Cooperative learning is learning that creates interaction between group members and teachers try to condition it by motivating students to always develop a sense of mutual need in a team

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(Jaelani, 2015). Social behavior learning is specifically developed to assist students in collaborating while learning. Cooperative learning is a learning paradigm in which students participate and interact with one another in small groups of four to six persons (Saputra et al., 2017). There are various variations of models that can be used in cooperative learning, namely (1) STAD, (2) Group Investigation, (3) Jigsaw, (4) Think-Pair-Share, (5) Inside-Outside Circle, (6) Make a Match, (7) Listening Team, (8) The Power of Two, and (9) Bamboo Dancing.

Jigsaw is one of the models of cooperative learning. Jigsaw type learning is learning in a learning group where there is interaction between each group member and has responsibility for the material in the group and the ability to master and teach the topic to the other members of the group (Lubis & Harahap, 2016). The initial group and the expert group are displayed in the puzzle cooperative learning paradigm. The origin group, or parent group of students, consists of students from different racial, ethnic, and socioeconomic backgrounds. While the expert group consists of members of different origin groups and is tasked with researching and studying certain subjects while carrying out tasks that will be communicated to members of the origin group. A number of specialists from the initial group have been combined to form the expert group. Being interconnected with each other where each student is able to convey the information needed to their teammates so that the goal in solving problems can be achieved is the key to the success of Jigsaw (Werdiningsih & Mukhlisin, 2021). In this learning students work in a team and are assigned to read and study a subject. Random selection is made for each member of the group who is designated as an expert in a particular field. Furthermore, the experts reported to the group and met with other groups to discuss the material learned then returned to their group to teach the material to their teammates (Widyastuti, 2015). The characteristic of the Jigsaw type that distinguishes it from other types of cooperatives is that there are study groups and specialist groups (Hibattulloh & Sofyan, 2014).

One of the learning models that can promote student activity, involvement, and knowledge of the material is cooperative learning. The Jigsaw cooperative learning model is one example (Nurfutriyanti, 2017). This learning model is possible to be applied to young children, because this type of children is also divided into several heterogeneous groups according to ability and gender, so that group characters are formed into parallels (Poerwati et al., 2020). The Jigsaw cooperative paradigm is intended to improve students' problem-solving and critical thinking abilities because in discussion activities students are grouped into specialist groups and origin teams to solve mathematical problems (Handayani, 2020).

In understanding abstract science, the ability to train critical thinking needs to be taught to students (Sarman & Soebagyo, 2022). Critical thinking is the ability of human thinking that has systematic and logical steps (Saviraningrum & Soebagyo, 2022). Thinking logically means being precise, which is an important skill for life and work to work effectively in all areas of life. The advantage in critical thinking, we can assess the level of thoroughness or truth of the question and without any information it is not easy to express what we want to convey (Zuhasni, 2022). In addition, mathematical creative thinking skills, namely the ability to think based on data and information, are available to find possible answers to such problems from different points of view on problems in each individual where it is more emphasized the suitability of answers and the versatility of answers (Yayuk et al., 2020). That is, creative thinking skills should belong to everyone (Florentina & Leonard, 2017). No less important, to find relationships from a representation of concepts and procedures, to grasp between mathematical themes and apply mathematical concepts in other fields or daily life, the capacity to make mathematical connections is required (Widarti, 2013).

The Jigsaw method of learning, which is derived from research findings, assists students in understanding the findings they make (Sari & Fitriani, 2018). In other studies there is an influence on the mathematical ability of students but there are also those that do not have a significant influence. Of course, in various studies there are different kinds of conclusions even though the variables studied have similarities. Based on the existing problems, Meta-analysts can provide comprehensive and in-depth conclusions on certain variables or topics that want to be discussed. This study can answer how much influence the Jigsaw method has based on the desired category variables. One of the results of this study is a significant improvement in students' mathematical abilities after attending the Jigsaw method lecture with discussion assessment and based only on the findings of the preliminary and final tests (Edriati et al., 2015).

## METHODS

This study focuses on quantitative data research analysis based on Google Scholar database sources, specifically to investigate *Jigsaw models* with *math ability*. The purpose of this analysis was to identify the magnitude of the influence on the Jigsaw learning method and to investigate the impact of characteristics on mathematical ability in determining the variation in effect size of each available research. Analysis using a meta-analysis approach is used to achieve this purpose. Meta-analysis is used to compare primary study with other scientific advancements in the form of drawing statistical findings in the form of effect size on quantitative data studies based on relevant themes (Rosdiana, 2021). The steps in compiling the meta-analysis, starting from; (1) choose the criteria for the article to be researched, (2) look for literature sources related to relevant research to be used, (3) code the article to be used, (4) conduct analysis and classification, (5) interpret findings based on the article under study (Sukmawati, 2020).

### Literary Search

This research uses the Google Scholar database as a location for document search. Furthermore, the use of Publish or Perish is applied as a reference in downloading studies related to the application of the Jigsaw method by combining keywords into Jigsaw, math ability (Eryanti & Soebagyo, 2021; Haniyah & Soebagyo, 2021; Sarman & Soebagyo, 2022). Seen in Figure 1, it is obtained that the search process for the application of the Jigsaw method on Google Scholar using the PoP application reaches 500 data.

Cites	Per year	Rank	Authors	Title	Year	Publication	Publisher	Type
42	9	3.00	1 N Rambe, E Syah...	The Effect of the Jigsaw Cooperative...	2020	Research and Critic in...	publissematicscholar.org	PDF
41	5.86	2	1 Dewi, MS Hidayat...	... of Geometric Teaching Materials...	2016	Journal of Education and...	ERIC	
14	2.80	3	3 Surnani, D Darhi...	The students' mathematical conc...	2018	Journal of Physics ...	scisearch.org	
34	6.80	4	OP Sari, E Syahput...	An analysis of spatial ability and s...	2018	American ...	article.elsevier.com/locate/j...	PDF
22	2.75	5	5 Sidiqah, Y Anggra...	Efektifitas Model Jigsaw Diarter...	2015	Jurnal Cakrawala Pendidikan...	jurnal.uny.ac.id	
4	1.33	6	AH Dians, D Dwijsa...	Mathematical creative thinking a...	2020	Unnes Journal of Mathem...	journal.unnes.ac.id	
23	6.25	7	7 E Sana, E Kartom...	Understanding Ability of Mathem...	2019	Journal of Primary Educat...	journal.unnes.ac.id	
8	4.00	9	H Sa'adah, S Syaf...	Student team achievement divisi...	2021	Desimal: Jurnal ...	ejournal.negeritanan.ac.id	
46	5.75	10	Y Masrudi, A Riy...	The discrepancy of students' mat...	2015	International Journal of...	ijgm.com	
1	0.20	11	DR Satri, E Surya...	Differences Ability of Problem Sol...	2018	3rd Annual International ...	atlantis-press.com	PDF
19	2.11	12	K Asri, M Hidayat...	Meningkatkan Kemampuan Pem...	2014	Jurnal Didaktika Matematika	journal.uny.ac.id	
21	2.33	13	C Young, E Cartm...	Gestures and speech input are inte...	2014	Proceedings of the ...	sciencedirect.com	PDF
40	3.45	14	C Chernis, C Bach...	The jigsaw technique and self-eff...	2012	European journal of sc...	Springer	
44	11.00	15	R Fanani, C Makom...	Visual and spatial working memo...	2019	Frontiers in Psychology	frontiersin.org	HTML
14	2.33	16	M Juliana, E Surya...	An Analysis Of Jigsaw Cooperative...	2017	OP Advance Research A...	researchgate.net	PDF
4	0.80	17	AA Satriyati, H Ma...	THE DIFFERENCE OF STUDENT'S ...	2018	Journal of Mathematics	ojs.umsida.ac.id	PDF
5	1.00	18	AA Satriyati, H Ma...	... OF STUDENT'S ACHIEVEMENT L...	2018	Infinity Journal	e-journal.diklatkangsi.ac...	

Figure 21. Google Scholar database search results (Jigsaw, Math ability)

### Literary Inclusion Criteria

Throughout the present investigation, the research that was successfully found using the PoP software was then collated based on the requirements listed following: (1) write keywords using English settings, then retrieve the Google Scholar database at a vulnerable time between 2010-2023, (2) statistical information is used to obtain the effect size value. And journals or study criteria that do not match will be removed from the analysis data, and (3) learning to use a quantitative approach where in quantitative data there must be control groups and experiments. Journals or papers with just a single sample and a qualitative approach will be excluded from the data analysis.

The data screening in this investigation was done using the PRISMA protocols shown in Figure 2.

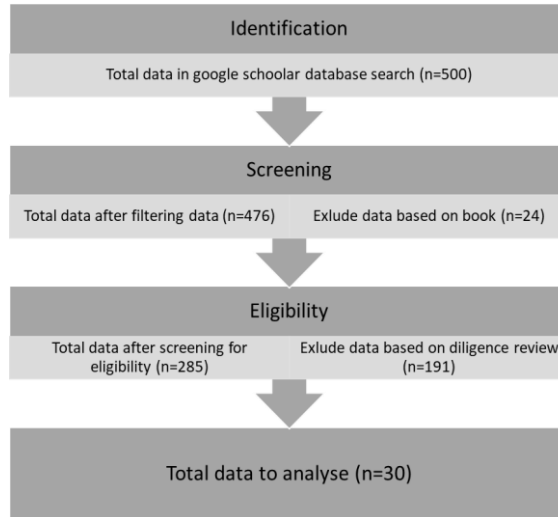


Figure 22. Filter data using PRISMA

### Coding

All studies that match the criteria are coded manually using a detailed coding scheme based on protocols. In this study, the instrument was carried out using the provision of codes (*categories*). Coding is done to separate individual data information into numerical data. A random sample of 5 valid studies was reproduced and divided among coders to determine reliability. The coder is given a copy of the article, as well as the coding form and protocol. To assess the reliability of these coders, the following formula is employed to calculate percent agreement (PA):

$$PA = \frac{N_A}{N_A + N_P} \times 100\%$$

In this scenario,  $N_A$  represents the total number of agreements, while  $N_P$  represents the entire number of disagreements.

### Statistical Analysis

The data was evaluated with the CMA application, with special attention paid to the effect size, which is defined as the influence of the Jigsaw approach on students' mathematical skills. The Comprehensive Meta-Analysis is beneficial for adjusting the effect size of research, including the overall effect size, P-value, Q-statistic, and truth interval. In addition, the program creates research forest plots and funnel plots. The g Hedges measure was utilized in this analysis, and the size effect was classified as less than 0.2 (negligible), 0.2 to 0.5 (small effect), 0.5 to 0.8 (moderate effect), 0.8 to 1.3 (big effect), and more than 1.3 (very large effect) (Cohen et al., 2007). The random effect technique was chosen as the estimation method since there is no assumption that all research have the same effect. The randomized effect model in this study was selected after a successful heterogeneity test. The p value is used to perform this test. If the p-value is less than 0.05, all studies will be identical, and the null hypothesis and homogeneity will be rejected. The rejection of the null hypothesis suggests that population parameters may not be measured with the same effect size across studies or study groups (Retnawati et al., 2018). There is evidence that different study categories have different effects on study effect sizes.

To avoid misrepresentation of results, publication bias is checked. Publication bias is the likelihood that studies appearing in published literature are considered statistically significant to be published (Cooper et al., 2009). In anticipation, a bias analysis was carried out on the funnel plot to see if the research was free from bias. When the distribution of impact sizes on vertical lines was symmetrical, publication bias was judged strong in this study. However, if the size distribution of the effect is not perfectly symmetrical, it is necessary to use the trim and fill method. If the observed

effects and virtual effects generated by randomized effects models are found to be similar, then the study is immune to publication bias.

## **RESULTS & DISCUSSION**

### ***Results***

#### **Literature Search Results**

The goal of this study was to determine whether the magnitude of the effect created had an effect on learning the Jigsaw method and mathematical competence based on category variables. Therefore, researchers try to search literature using PoP (Publish or Perish) software by applying several criteria. The first criterion, researchers use vulnerable research time in 2010 – 2023. Furthermore, the second criterion of researchers used the keywords Jigsaw and Math ability, and the maximum number of results was limited to 500 data. From the topics used, 501 articles were collected, with 24 data coming from books and the rest coming from journals, citations and documents.

#### **Literature Selection Results**

After setting criteria for literature search, the researcher converts the data into excel and eliminates the data in the appropriate journal. First, researchers filter data that is included in journals or articles. Second, researchers use a quantitative approach to collect data that has an experimental class and a control class. Third, researchers collect statistical data such as the number of samples, average values and standard deviations. This statistical data aims to calculate the size of the effect to be studied. Furthermore, screening through the PRISMA method is carried out to ensure the accuracy of the data obtained. Not only that, but researchers must guarantee that the journal's title and theme are consistent with the criteria variables.

#### **Results Criteria**

The results of the criteria in this study focused on vulnerable years 2010 - 2023. The selection of criteria on this year's vulnerability was carried out to ensure that the available research is up-to-date. From the results of the criteria that have been filtered, researchers consider choosing research sourced from journals and proceedings. In addition, researchers also obtained various journals from various countries with the same topic, ranging from Asian to European countries. Furthermore, researchers consider the degree of education beginning with (pre-school, elementary, junior high, high school, and university). The many variations that have been studied at this level of education add to the accuracy of a study. Furthermore, researchers also looked at the number of sample sizes in a study and paid attention to whether each of these journals had a control class and an experimental class. The selected research is also equipped with post-test and pre-test data, average values and standard deviations to see the extent of the data spread and whether there are data deviations in the average value.

#### **Statistical Analysis Results**

The results of the study here aim to answer the research question. Figure 3 depicts the findings of a meta-analysis of 30 filtered and collected data from Google Scholar. Figure 3 contains the identification of the names of the studies. Furthermore, the magnitude of the effect is shown which contains the results of the intervention. It can be seen that there is 1 data that is less than 0 or under consideration, while the average confidence interval that stretches horizontally or is more than 0 is on the right. This means that the effects of the intervention are beneficial. In addition, figure 3 also shows the heterogeneity of a data to see discrepancies in the source of findings from the study.

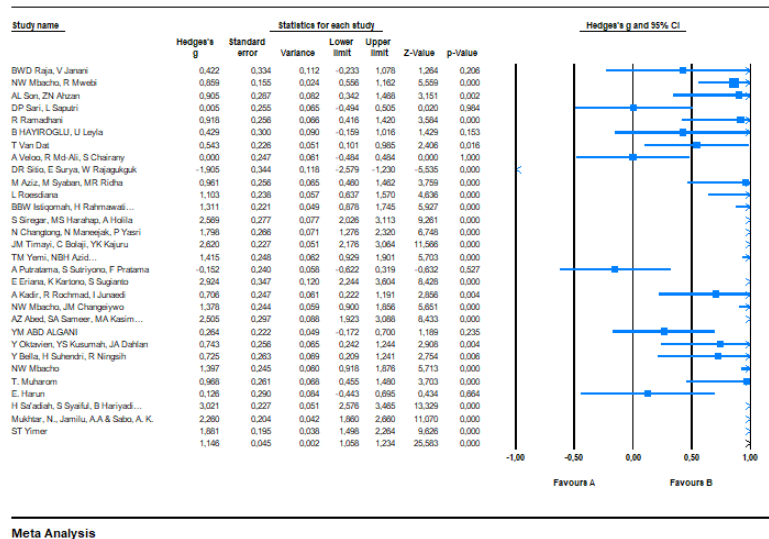


Figure 23. Research Forest Plot

According to Figure 3, there is an inconsistent response rate. It is clear that the research is likely to be diverse. As a result, it must be statistically examined such that the starting assumptions are consistent with the estimation approach.

Table 9. Meta Results - Analysis according to the Estimation method

Model	N	Hedge's	andard er	Test of null		Q	P	Decision
				Z-value	P-value			
Fixed-effects	30	1.146	0.045	25.583	0.000	447.062	0.000	Reject
Random-effects	30	1.095	0.177	6.189	0.000			

Table 1 displays the findings of a meta-analysis of 30 papers from conferences and international journals. Table 1 shows that the P value is 0.05, indicating that each study has a diverse impact size. Therefore, a fixed effect model with a very high effect size of 1,146 was used. Using a null test obtained P less than 0.05 with a fixed effects model. In addition, a z value of 25,583 was obtained indicating that the research results were significant for  $P < 0.05$  (Musna et al., 2021). To put it another way, the Jigsaw-type learning model has a big impact on mathematical ability.

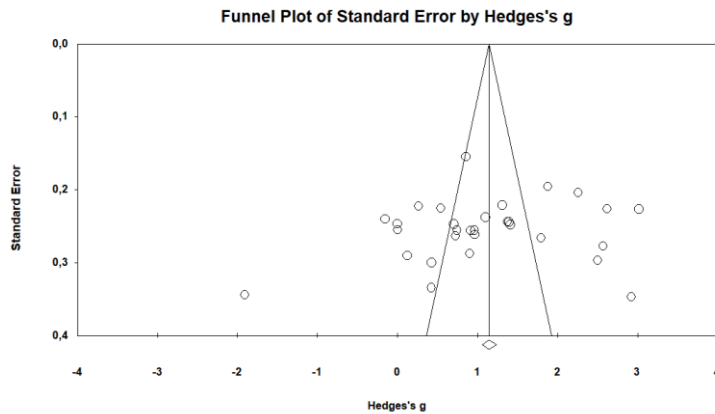


Figure 24. Funnel plot of 30 samples

Then, as shown in Figure 5, we will show a funnel plot with the research spread out and not symmetrical in the funnel, requiring trim and fill to check whether there is a difference with the influence of publication bias.

#### Duval and Tweedie's trim and fill

	Fixed Effects			Random Effects			Q Value
	Studies Trimmed	Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit
<b>Observed values</b>		1,14597	1,05817	1,23376	1,09469	0,74799	1,44139
<b>Adjusted values</b>	0	1,14597	1,05817	1,23376	1,09469	0,74799	1,44139

Figure 25. Trim and Fill

The findings of trim and fill indicate that there is no difference or opposite according to the fixed effect model, so no research or study is trimmed or added to this study.. The overall effect size is 1.14597 rounded up to 1.146 is a very high value for an effect size.

Furthermore, in addressing the following question, it is demonstrated that the estimation approach, as previously stated, matches the fixed effect model. This shows that the effect sizes of each study are varied, necessitating a detailed examination of the categorical factors influencing the association between the Jigsaw learning model and mathematical competence. As a result, Table 2 shows the summary results of the category variable analysis.

Table 10. Summary of Category Variable Analysis

No	Category Variable	Group	N	Combined Effect Size (Hedge's g)	Test of null (2-Tail)		Heterogeneity		P-value	Decision
					Z	P-value	Between-Classes Effect (Q-value)	Df (Q)		
1	Country	Indonesia	15	0.99	3.439	0.001	0.331	1	0.565	Reject $H_0$
		Overseas	15	1.199	5.412	0				
2	Educational level	University	4	1.172	3.797	0	32.466	4	0	Reject $H_0$
		High School	9	0.942	3.672	0				
		Primary School	15	1.09	3.702	0.000				
		Elementary	1	2.924	8.428	0.000				
		Pre School	1	0.429	1.429	0.153				
3	Sample Size	30 or less	7	0.114	0.361	0.000	12.005	1	0.001	Reject $H_0$
		31 or more	23	1.384	7.51	0.000				
4	Publication Source	Journal	29	0.178	5.919	0.000	19.84	1	0	Reject $H_0$
		Proceding	1	2.26	11.07	0.000				



### **Country**

The effect size in Indonesian study was 3,439, whereas the effect size in international research was 5,412. According to the heterogeneity of  $Q$ -value = 0.331 and  $p > 0.05$ , studies on the Jigsaw learning model conducted in Indonesia and abroad have no impact on students' mathematical abilities.

### **Education Level**

According to Table 2, the sample size at the education level is as follows: Pre-school (0.429), Elementary (2.924), Junior High School (1.09), Senior High School (0.942), and University (1.172). Heterogeneity tests yielded  $Q$ -value = 32.466 and  $p > 0.05$ , indicating that the application of Jigsaw learning to mathematical abilities was influential at all stages of schooling, from pre-primary to university.

### **Sample Size**

Based on Table 2. It was shown that a sample size with a group of 30 or less had an effect size of 0.114, while a sample size with a group of 31 or more had an effect size of 1.384. Based on the heterogeneity test,  $Q$ -value = 12.005 and  $p < 0.05$ . In this situation, it suggests that the sample size influences Jigsaw technique learning with students' mathematical skills.

### **Publication Source**

According to the publication source, the effect size of journal research was 0.178, whereas the effect size of proceedings research was 2.26. Judging from the heterogeneity of  $Q$ -value = 19.84 and  $p < 0.05$ , the entire paper shows that Jigsaw learning affects students' mathematical abilities.

### **Discussion**

Essentially, the purpose of this study is to determine whether the Jigsaw approach has a significant impact on students' mathematical abilities. Based on the analysis, an effect size of 1,146 was obtained, which shows that this study has a considerable influence. In accordance with the research that has been conducted, there is a possibility that students can contribute to solving problems in group discussions using the Jigsaw learning model, due to its significant influence (Tamur et al., 2021).

The number of subjects studied in this study was 1252 with an average of 69 people. In this case, the effect size of 1,146 shows that the Jigsaw method affects mathematical ability (Cohen et al., 2018). In line with other studies, learning using the Jigsaw method is more fun than ordinary learning because students can find information from other groups (Wardani, 2015). Next, researchers conducted an analysis based on categorical variables. It can be seen that the amount of the influence in this study is clarified beginning with the level of education, country, sample size, and publication source.

Analysis of country categories found that research in Indonesia and abroad showed no influence between the Jigsaw learning model on mathematical ability. In this study, the number of samples from 30 papers is comparable. This means that in addition to Indonesia, abroad this research has been carried out a lot even not a few who use modifications to the variables studied with the main variable being Jigsaw learning. For example, research (Abed et al., 2020) that predicts Jigsaw-type learning strategies on students' mathematics learning achievement. Furthermore, other data show that the Jigsaw technique of learning geometric information is more effective than the lecture method (Timayi et al., 2015). Another study related to Jigsaw learning in Turkey states that there is an influence on students' abilities in natural science laboratory practice (Karacop, 2017).

Next, analyze category variables related to education level. Judging from the comparison of the magnitude of the effect size between Pre-School: Elementary: Junior High: High School: University (0.429: 2.924: 1.09: 0.942: 1.172) the results show that learning the Jigsaw method has a major effect on the elementary level. The findings also show that learning mathematics using the Jigsaw method is more effective at the elementary level than at other levels. According to research (Sulistiyowati & Astuti, 2020), the Jigsaw method of learning has a high level of cooperation as indicated by post-test and pre-test findings. Although this is a contradiction where learning mathematics using the Jigsaw method at the high school level affects students' mathematical

communication skills (Yeubun et al., 2020).

Learning mathematics using the Jigsaw method, as shown in Table 2, also demonstrates that many research samples were collected at the secondary school level. This happens because the level of thinking has entered the formal stage. On the other hand, this learning triggers the psychology of students to be curious about their peers (Utami et al., 2021). In addition to their mathematical abilities, students' mathematical successes have beneficial consequences after the Jigsaw learning approach is implemented (Ribut, 2021). However, other studies on cooperative learning with the type of Think Pair Share aided by comics show that it is no better than not using comics to develop problem-solving skills (Turyanto et al., 2019). However, Pair Check cooperative learning has been shown to improve students' overall cooperative abilities (Wijayanti & Kusdiyanta, 2019).

In this study, sample size was also applied to categorical variables to clarify the size of the effect on the study. The findings showed that (31 or more) had a greater influence than other categories. This study also conducted an analysis of publication sources on categorical variables. Based on the findings, 1 literature was obtained from proceedings and 29 other literature was obtained from journals. These data imply that the study was free of publication bias, which is supported by trim and fill.

Many studies are not taken or do not fall into the required category while examining this research. Such research conducted by (Budiawan & Arsani, 2013) using the same variables but carried out on sports subjects. In addition, there are also some unqualified studies where there is a lack of pretest data as a control study. Of the 500 data collected, only about 30 studies were included in the requirements after several screenings. And obviously, it does not end there; this study needs to be researched further to determine its effectiveness.

## CONCLUSION

This research was conducted by taking articles from proceedings and international journals in the range of 2010 – 2023. A meta-analysis research with 30 samples revealed a fixed effect with an effect size of 1,146, indicating that mastering the Jigsaw technique had a significant impact on students' mathematical abilities. This means that Jigsaw learning is still relevant to improve students' mathematical skills. Furthermore, this study was conducted analysis based on category variables divided into four variables. Based on the analysis of education levels, it was discovered that the degree of the influence varied depending on the study. However, learning using the Jigsaw method is more influential at the elementary level than other levels. In addition, the number of samples in 31 or more has a higher effectiveness and also publication sources based on journals have more significant influence, while analysis in countries does not have an influence on both research from Indonesia and abroad.

In the world of education, the application of the Jigsaw method is quite effective, as evidenced by the findings of several studies, particularly at the elementary level, where students enjoy playing and learning in groups, exchanging information, and working together to find information. This research has limitations because the sample in this study was obtained from Google Scholar using PoP software which means there are still many other research samples that were not carried out because of access or paid constraints. Further research requires good collaboration to review more deeply about this research.

## CONFLICT OF INTEREST

## ACKNOWLEDGEMENT

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**5. Bukti konfirmasi revisi kedua, dan artikel  
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Is the Jigsaw Model Still Relevant for Improving Mathematical Ability?  
Meta-Analysis Studies

Author 1, Author 2, Author 3, Author 4

Received:	<b>Abstract</b>
Revised:	The Jigsaw learning model focuses on student activities in learning in general and also has an influence on students' mathematical abilities, but there are also some that do not have a significant influence. This research attempts to answer how much influence the Jigsaw model has based on the desired categorical variables. Therefore, meta-analysis research is needed to provide comprehensive and in-depth conclusions about the application of the Jigsaw model to students' mathematical abilities. Comprehensive Meta-Analysis (CMA) is used to evaluate a property's value based on comparisons to similar properties in the same area. Data was obtained from Publish or Perish (PoP) with a total of 500 articles from 2010 to 2023 with the Google Scholar database. The number of journals that meet the requirements and will be analyzed is 30 sample articles with a total of 1252 students. The moderator variables in this study consider country, education level, sample size and publication source. Based on research findings, the Jigsaw model has a significant influence on numeracy skills (P-value 0.05), with an effect size of 1.146 which is classified as very high based on fixed effects and a standard error of 0.045. The research results show that the Jigsaw model is still relevant for improving students' mathematical abilities, especially at the elementary school level. This meta-analysis study reveals that there is no difference in the results of implementing the Jigsaw model on students' mathematical abilities in all country categories.
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INTRODUCTION

Recognize mathematics as an abstract science that is the basis for achieving other sciences. Mathematics complements all existing sciences ranging from science, technology, art and many others (Kamarullah, 2017). The level of difficulty in mathematics is often used as a benchmark in achieving success. No wonder many of the nation's students are required to be proficient in mathematics. Sometimes the difficulty in solving abstract problems often makes interest in learning decrease so that you are lazy to learn, this is a trigger factor for problems in learning (Siswono, 2014). In mathematics, mathematical ability is not only measured on one ability. Mathematical abilities are grouped into five understandings ranging from mathematical understanding, problem solving, reasoning, connection and communication (Sumarmo, 2012). Mathematics learning must instill rational thinking processes with the laws of mathematical logic to develop thinking processes in solving mathematical problems (Maarif et al., 2018). In understanding logic, of course, requires motivation and good learning and teaching. Not all teaching provided is able to make some students interested in learning. Therefore, as a good teacher, there needs to be variety in providing learning models. This variant is used to ensure the learners grasp the topic and that objectives for learning are achieved. Currently, there are many learning models that are often found, ranging from Problem Based Learning (PBL), Project Based Learning (PBjL), Realistic Mathematics Education (RME), to Cooperative Learning (CL). The development of technology, a lot of research related to learning. In fact, not a few studies that vary learning with other methods.

Cooperative learning was first studied in 1898 by Roger and Johnson in about 600 experiments. Cooperative learning is learning that creates interaction between group members and teachers try to condition it by motivating students to always develop a sense of mutual need in a team



(Jaelani, 2015). Social behavior learning is specifically developed to assist students in collaborating while learning. Cooperative learning is a learning paradigm in which students participate and interact with one another in small groups of four to six persons (Saputra et al., 2017). There are various variations of models that can be used in cooperative learning, namely (1) Student Team Achievement Division (STAD), (2) Group Investigation, (3) Jigsaw, (4) Think-Pair-Share, (5) Inside-Outside Circle, (6) Make a Match, (7) Listening Team, (8) The Power of Two, and (9) Bamboo Dancing.

Jigsaw is one of the models of cooperative learning. One of the reasons why the Jigsaw model was chosen to be researched through meta-analysis is because there are not many similar studies that specifically examine it in mathematics learning. Jigsaw type learning is learning in a learning group where there is interaction between each group member and has responsibility for the material in the group and the ability to master and teach the topic to the other members of the group (Lubis & Harahap, 2016). The initial group and the expert group are displayed in the puzzle cooperative learning paradigm. The origin group, or parent group of students, consists of students from different racial, ethnic, and socioeconomic backgrounds. While the expert group consists of members of different origin groups and is tasked with researching and studying certain subjects while carrying out tasks that will be communicated to members of the origin group. A number of specialists from the initial group have been combined to form the expert group. Being interconnected with each other where each student is able to convey the information needed to their teammates so that the goal in solving problems can be achieved is the key to the success of Jigsaw (Werdiningsih & Mukhlisin, 2021). In this learning students work in a team and are assigned to read and study a subject. Random selection is made for each member of the group who is designated as an expert in a particular field. Furthermore, the experts reported to the group and met with other groups to discuss the material learned then returned to their group to teach the material to their teammates (Widyastuti, 2015). The characteristic of the Jigsaw type that distinguishes it from other types of cooperatives is that there are study groups and specialist groups (Hibattulloh & Sofyan, 2014).

One of the learning models that can promote student activity, involvement, and knowledge of the material is cooperative learning. The Jigsaw cooperative learning model is one example (Nurfitriyanti, 2017). This learning model is possible to be applied to young children, because this type of children is also divided into several heterogeneous groups according to ability and gender, so that group characters are formed into parallels (Poerwati et al., 2020). The Jigsaw cooperative paradigm is intended to improve students' problem-solving and critical thinking abilities because in discussion activities students are grouped into specialist groups and origin teams to solve mathematical problems (Handayani, 2020).

In understanding abstract science, the ability to train critical thinking needs to be taught to students (Sarman & Soebagyo, 2022). Critical thinking is the ability of human thinking that has systematic and logical steps (Saviraningrum & Soebagyo, 2022). Thinking logically means being precise, which is an important skill for life and work to work effectively in all areas of life. The advantage in critical thinking, we can assess the level of thoroughness or truth of the question and without any information it is not easy to express what we want to convey (Zuhasni, 2022). In addition, mathematical creative thinking skills, namely the ability to think based on data and information, are available to find possible answers to such problems from different points of view on problems in each individual where it is more emphasized the suitability of answers and the versatility of answers (Yayuk et al., 2020). That is, creative thinking skills should belong to everyone (Florentina & Leonard, 2017). No less important, to find relationships from a representation of concepts and procedures, to grasp between mathematical themes and apply mathematical concepts in other fields or daily life, the capacity to make mathematical connections is required (Widarti, 2013).

The Jigsaw model, which is derived from research findings, assists students in understanding the findings they make (Sari & Fitriani, 2018). In other studies there is an influence on the mathematical ability of students but there are also those that do not have a significant influence. Of course, in various studies there are different kinds of conclusions even though the variables studied have similarities. Based on the existing problems, Meta-analysis can provide comprehensive and in-depth conclusions on certain variables or topics that want to be discussed. This study can answer how much influence the Jigsaw model has based on the desired category variables. One of the research results showed that there was a significant increase in students' mathematical abilities after attending Jigsaw model lectures with discussion assessments and based only on the findings of the initial and

final tests (Edriati et al., 2015).

## METHODS

This study focuses on quantitative data research analysis based on Google Scholar database sources, specifically to investigate *Jigsaw models* with *math ability*. The purpose of this analysis was to identify the magnitude of the influence on the Jigsaw model and to investigate the impact of characteristics on mathematical ability in determining the variation in effect size of each available research. Analysis using a meta-analysis approach is used to achieve this purpose. Meta-analysis is used to compare primary study with other scientific advancements in the form of drawing statistical findings in the form of effect size on quantitative data studies based on relevant themes (Rosdiana, 2021). The steps in compiling the meta-analysis, starting from; (1) choose the criteria for the article to be researched, (2) look for literature sources related to relevant research to be used, (3) code the article to be used, (4) conduct analysis and classification, (5) interpret findings based on the article under study (Sukmawati, 2020).

### Literary Search

This research uses the Google Scholar database as a location for document search. Furthermore, the use of Publish or Perish is applied as a reference in downloading studies related to the application of the Jigsaw model by combining keywords into Jigsaw and math ability (Eryanti & Soebagyo, 2021; Haniyah & Soebagyo, 2021; Sarman & Soebagyo, 2022). Seen in Figure 1, it is obtained that the search process for the application of the Jigsaw model on Google Scholar using the PoP application reaches 500 data.

The screenshot shows the Google Scholar search interface. At the top, search terms are listed: 'jigsaw, math ability from 2010 to 2023', 'math props from 2010 to 2023', 'jigsaw, mathematical ability', 'mathematical communication', and 'ethnomathematics'. Below this, the search results are displayed in a table format. The table has columns for Cites, Per year, Rank, Authors, Title, Year, Publication, Publisher, and Type. The first few results are as follows:

Cites	Per year	Rank	Authors	Title	Year	Publication	Publisher	Type
9	3.00	1	H Rambe, E Spah...	The Effect of the Jigsaw Cooperat...	2020	Research and Critic in ...	gajda.lemanticscholar.org	PDF
41	5.86	2	D Dwi, M Hidayat	... of Geometric Teaching Materials...	2016	Journal of Education and ...	ERIC	
14	2.80	3	S Sumardi, D Darh...	The students' mathematical conc...	2018	Journal of Physics ...	scipress.org	PDF
34	6.80	4	OP Sari, E Spahpud...	An analysis of spatial ability and ...	2018	American ...	article.acereducationrese...	
22	2.75	5	S Edrati, V Anggra...	Mathematics Model Jigsaw Dierne...	2015	Jurnal Cakrawala Pendidikan	jurnal.uny.ac.id	
4	1.33	6	AH Diani, D Djuj...	Mathematical creative thinking a...	2020	Unnes Journal of Mathem...	journal.unnes.ac.id	
25	6.25	7	E Eriani, E Kartom...	Understanding Ability of Mathem...	2019	Journal of Primary Educat...	journal.unnes.ac.id	
2	0.67	8	UD Yudianto, A Na...	The Effect of Jigsaw Cooperative ...	2020	Konstanta: Jurnal Ilmiah ...	journal.lppmuindia.ac.id	
9	4.00	9	H Sa'adah, S Spah...	Student team achievement divis...	2021	Desimal: Jurnal ...	ejournal.stadriestrian.ac.id	
46	5.75	10	F Muzenda, A Riy...	The discrepancy of students' mat...	2013	International Journal of ...	ijer.com	PDF
1	0.20	11	OR Sato, E Surya...	Difference Ability of Problem Sol...	2018	1st Annual International ...	attitudepress.com	
19	2.11	12	K Auri, M Bhan...	Manajemen Kemampuan Pem...	2014	Jurnal Didaktik Matematika	jurnal.uny.ac.id	PDF
21	2.33	13	C Young, E Cartm...	Gestures and speech input are inte...	2014	Proceedings of the ...	escholarship.org	
40	5.45	14	C Dierani, C Bach...	The Jigsaw technique and self eff...	2012	European journal of psych...	Springer	
44	11.00	15	R Faras, C Meloni...	Visual and spatial working memo...	2019	Frontiers in Psychology	frontiersin.org	HTML
14	2.33	16	M Juliana, E Surya	An Analysis Of Jigsaw Cooperative...	2017	OF Advance Research A...	researchgate.net	PDF
4	0.80	17	Ain Sitijah, H Ma...	THE DIFFERENCE OF STUDENTS' ...	2018	Journal of Mathematics ...	core.ac.uk	PDF
5	1.00	18	Ain Sitijah, H Ma...	OF STUDENTS' ACHIEVEMENT L...	2018	Infodity Journal	e-journal.aituphasing.ac...	

Figure 26. Google Scholar database search results (Jigsaw, Math ability)

### Literary Inclusion Criteria

Throughout the present investigation, the research that was successfully found using the PoP software was then collated based on the requirements listed following: (1) write keywords using English settings, then retrieve the Google Scholar database at a vulnerable time between 2010-2023 due to the novelty and dynamics of research, (2) statistical information is used to obtain the effect size value. And journals or study criteria that do not match will be removed from the analysis data, and (3) learning to use a quantitative approach where in quantitative data there must be control groups and experiments. Journals or papers with just a single sample and a qualitative approach will be excluded from the data analysis. The data screening in this investigation was done using the PRISMA protocols shown in Figure 2.

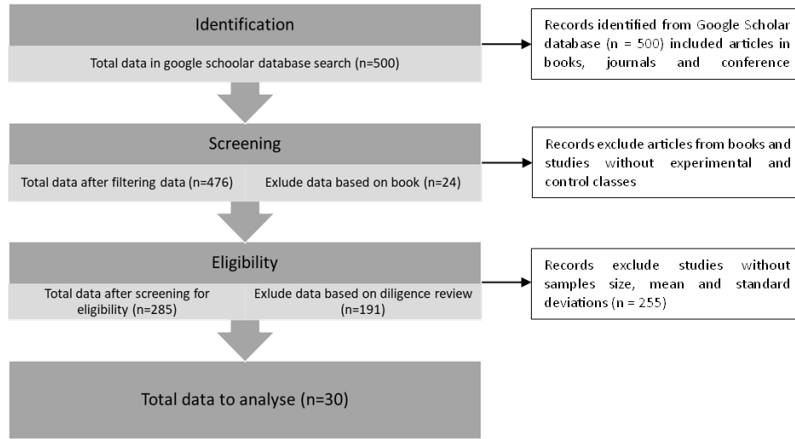


Figure 27. Filter data using PRISMA

### Coding

All studies that match the criteria are coded manually using a detailed coding scheme based on protocols. In this study, the criteria was carried out using the provision of codes (*categories*). Coding is carried out to separate individual data information into numerical data. Random samples from 5 valid studies were reproduced and divided among 3 coders from one research group to determine reliability. Three coders were provided with a copy of the article, as well as the coding form and protocol. To assess the reliability of this coder, the following formula was used to calculate the percentage agreement (PA). In this scenario,  $N_A$  represents the total number of agreements, while  $N_p$  represents the entire number of disagreements.

$$PA = \frac{N_A}{N_A + N_p} \times 100\%$$

### Statistical Analysis

The data was evaluated with the CMA application, with special attention paid to the effect size, which is defined as the influence of the Jigsaw approach on students' mathematical skills. The Comprehensive Meta-Analysis is beneficial for adjusting the effect size of research, including the overall effect size, P-value, Q-statistic, and confidence interval. In addition, the program creates research forest plots and funnel plots. The g Hedges measure was utilized in this analysis, and the size effect ( $\delta$ ) was classified as  $\delta < 0.2$  (negligible),  $0.2 \leq \delta < 0.5$  (small effect),  $0.5 \leq \delta < 0.8$  (moderate effect),  $0.8 \leq \delta < 1.3$  (big effect), and  $1.3 \leq \delta$  (very large effect) (Cohen et al., 2007). The random effect technique was chosen as the estimation method since there is no assumption that all research have the same effect. The randomized effect model in this study was selected after a successful heterogeneity test. The p value is used to perform this test. If the p-value is less than 0.05, all studies will be identical, and the null hypothesis and homogeneity will be rejected. The rejection of the null hypothesis suggests that population parameters may not be measured with the same effect size across studies or study groups (Retnawati et al., 2018). There is evidence that different study categories have different effects on study effect sizes.

To avoid misrepresentation of results, publication bias is checked. Publication bias is the likelihood that studies appearing in published literature are considered statistically significant to be published (Cooper et al., 2009). In anticipation, a bias analysis was carried out on the funnel plot to see if the research was free from bias. When the distribution of impact sizes on vertical lines was symmetrical, publication bias was judged strong in this study. However, if the size distribution of the effect is not perfectly symmetrical, it is necessary to use the trim and fill method. If the observed effects and virtual effects generated by randomized effects models are found to be similar, then the study is immune to publication bias.

## RESULTS & DISCUSSION

### *Results*

#### **Literature Search Results**

The goal of this study was to determine whether the magnitude of the effect created had an effect on learning the Jigsaw model and mathematical competence based on category variables. Therefore, researchers try to search literature using PoP software by applying several criteria. The first criterion, researchers use vulnerable research time in 2010 – 2023. Furthermore, the second criterion of researchers used the keywords Jigsaw and Math ability, and the maximum number of results was limited to 500 document. From the topics used, 500 articles were collected with 24 data coming from books and the rest comes from a combination of journals and conference proceedings.

#### **Literature Selection Results**

After setting criteria for literature search, the researcher converts the data into excel and eliminates the data in the appropriate journal. First, researchers filter data that is included in journals and conference proceedings. Second, researchers use a quantitative approach to collect data that has an experimental class and a control class. Third, researchers collect statistical data such as the samples size, mean and standard deviations. This statistical data aims to calculate the size of the effect to be studied. Furthermore, screening through the PRISMA method is carried out to ensure the accuracy of the data obtained. Not only that, but researchers must guarantee that the journal's title and theme are consistent with the criteria variables.

#### **Results Criteria**

The results of the criteria in this study focused on vulnerable years 2010 - 2023. The selection of criteria on this year's vulnerability was carried out to ensure that the available research is up-to-date. From the results of the criteria that have been filtered, researchers consider choosing research sourced from journals and proceedings. In addition, researchers also obtained various journals from various countries with the same topic, ranging from Asian to European countries. Furthermore, researchers consider the degree of education beginning with (pre-school, elementary, junior high, high school, and university). The many variations that have been studied at this level of education add to the accuracy of a study. Furthermore, researchers also looked at the number of sample sizes in a study and paid attention to whether each of these journals had a control class and an experimental class. The selected research is also equipped with post-test and pre-test data, mean and standard deviations to see the extent of the data spread and whether there are data deviations in the mean.

#### **Statistical Analysis Results**

The results of the study here aim to answer the research question. Figure 3 depicts the findings of a meta-analysis of 30 filtered and collected data from Google Scholar. Figure 3 contains the identification of the names of the studies. Furthermore, the magnitude of the effect is shown which contains the results of the intervention. It can be seen that there is 1 data that is less than 0 or under consideration, while the average confidence interval that stretches horizontally or is more than 0 is on the right. This means that the effects of the intervention are beneficial. In addition, Figure 3 also shows the heterogeneity of a data to see discrepancies in the source of findings from the study.

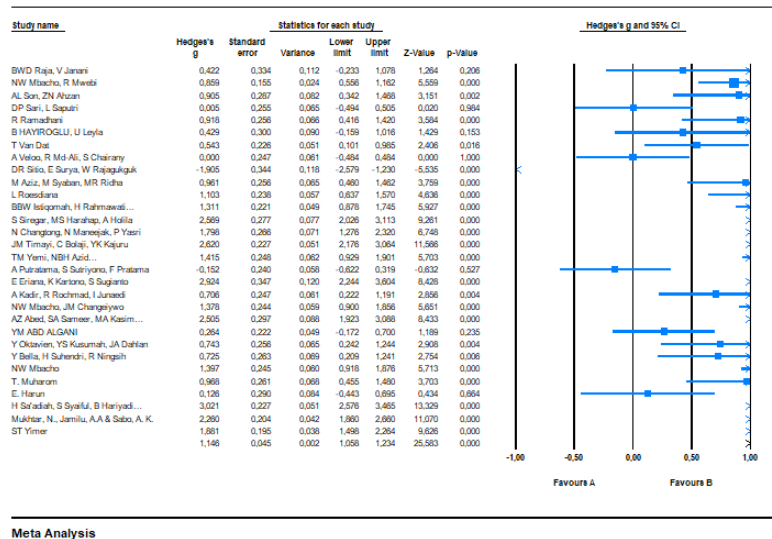


Figure 28. Research Forest Plot

According to Figure 3, there is an inconsistent response rate. It is clear that the research is likely to be diverse. As a result, it must be statistically examined such that the starting assumptions are consistent with the estimation approach.

Model	N	Hedge's	Standard error	Test of null		Q	P	Decision
				Z-value	P-value			
Fixed-effects	30	1.146	0.045	25.583	0.000	447.062	0.000	Reject
Random-effects	30	1.095	0.177	6.189	0.000			

Figure 29. Meta Results - Analysis according to the Estimation method

Figure 4 displays the findings of a meta-analysis of 30 articles from international conference proceedings and journals. Several examples of international conference and journal proceedings can be seen in Figure 1. Figure 4 shows that the P value is 0.05, indicating that each study has a diverse effect size. Therefore, a fixed effect model with a very high effect size of 1.146 was used. Using a null test obtained P less than 0.05 with a fixed effects model. In addition, a z value of 25,583 was obtained indicating that the research results were significant for  $P < 0.05$  (Musna et al., 2021). To put it another way, the Jigsaw-type learning model has a big impact on mathematical ability.

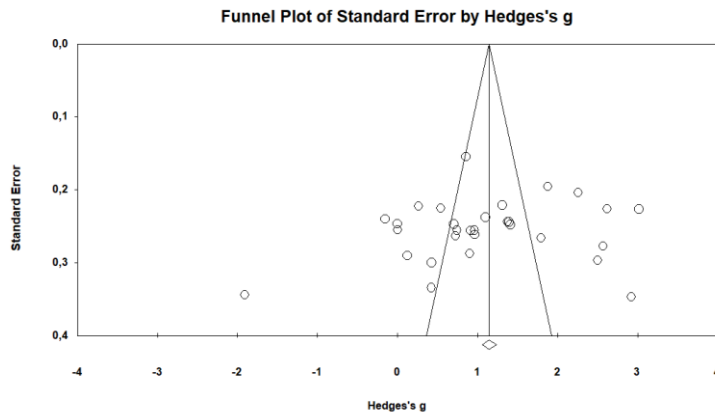


Figure 30. Funnel plot of 30 samples

Then, as shown in Figure 4, we will show a funnel plot with the research spread out and not symmetrical in the funnel, requiring trim and fill to check whether there is a difference with the influence of publication bias. In addition, trim and fill was performed to estimate potentially missing studies due to publication bias.

#### Duval and Tweedie's trim and fill

	Fixed Effects			Random Effects			Q Value
	Studies Trimmed	Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit
<b>Observed values</b>		1,14597	1,05817	1,23376	1,09469	0,74799	1,44139
<b>Adjusted values</b>	0	1,14597	1,05817	1,23376	1,09469	0,74799	1,44139

Figure 31. Trim and Fill

The findings of trim and fill in Figure 5 indicate that there is no difference or opposite according to the fixed effect model, so no research or study is trimmed or added to this study. The overall effect size is 1.14597 rounded up to 1.146 is a very high value for an effect size.

Furthermore, in addressing the research question, it is demonstrated that the estimation approach, as previously stated, matches the fixed effect model. This shows that the effect sizes of each study are varied, necessitating a detailed examination of the categorical factors influencing the association between the Jigsaw learning model and mathematical competence. As a result, Figure 6 shows the summary results of the category variable analysis.

No	Variabel Moderator	Group	N	Combined Effect Size (Hedge's g)	Test of null (2-Tail)		Heterogeneity			Decision
					Z	P-value	Between-Classes Effect (Q-value)	Df (Q)	P-value	
1	Country	Indonesia	15	0.99	3.439	0.001	0.331	1	0.565	Accept $H_0$
		Overseas	15	1.199	5.412	0				Reject $H_0$
2	Educational Level	University	4	1.172	3.797	0	32.466	4	0	Reject $H_0$
		High School	9	0.942	3.672	0				
		Primary School	15	1.09	3.702	0.000				
		Elementary	1	2.924	8.428	0.000				
3	Sample Size	Pre School	1	0.429	1.429	0.153	12.005	1	0.001	Reject $H_0$
		30 or less	7	0.114	0.361	0.000				
4	Publication Source	31 or more	23	1.384	7.51	0.000	19.84	1	0	Reject $H_0$
		Journal	29	0.178	5.919	0.000				
		Procciding	1	2.26	11.07	0.000				

Figure 32. Summary of Category Variable Analysis

### **Country**

The effect size in Indonesian study was 3.439, whereas the effect size in international research was 5.412. According to the heterogeneity of  $Q$ -value = 0.331 and  $p > 0.05$ , it is clear that research in Indonesia has a significant effect, as does research abroad. Further testing shows that research in Indonesia and abroad has effects that are not significantly different. This means that the results of Indonesian and foreign research are identical.

### **Education Level**

According to Figure 6, the effect size at the education level is as follows: Pre-school (0.429), Elementary (2.924), Junior High School (1.09), Senior High School (0.942), and University (1.172). Heterogeneity tests yielded  $Q$ -value = 32.466 and  $p < 0.05$ , indicating that the application of Jigsaw learning to mathematical abilities was influential at all stages of schooling, from pre-primary to university.

### **Sample Size**

Based on Table 2. It was shown that a sample size with a group of 30 or less had an effect size of 0.114, while a sample size with a group of 31 or more had an effect size of 1.384. Based on the heterogeneity test,  $Q$ -value = 12.005 and  $p < 0.05$ . In this situation, it suggests that the sample size influences Jigsaw model with students' mathematical abilities.

### **Publication Source**

According to the publication source, the effect size of journal research was 0.178, whereas the effect size of proceedings research was 2.26. Judging from the heterogeneity of  $Q$ -value = 19.84 and  $p < 0.05$ , publication type shows that Jigsaw learning affects students' mathematical abilities.

### **Discussion**

Essentially, the purpose of this study is to determine whether the Jigsaw approach has a significant impact on students' mathematical abilities. Based on the analysis, an effect size of 1.146 was obtained, which shows that this study has a considerable influence. In accordance with the research that has been conducted, there is a possibility that students can contribute to solving problems in group discussions using the Jigsaw learning model, due to its significant influence (Tamur et al., 2021).

The number of subjects studied in this study was 1252 with an average of 69 students. In this case, the effect size of 1.146 shows that the Jigsaw model affects mathematical ability (Cohen et al., 2018). In line with other studies, learning using the Jigsaw model is more fun than ordinary learning because students can find information from other groups (Wardani, 2015). Next, researchers conducted an analysis based on categorical variables. It can be seen that the amount of the influence in this study is clarified beginning with the level of education, country, sample size, and publication source.

Analysis of country categories found that research in Indonesia and abroad showed that research in Indonesia and abroad has effects that are not significantly different. This means that the results of Indonesian and foreign research are identical. In this study, the number of samples from 30 papers is comparable. This means that in addition to Indonesia, abroad this research has been carried out a lot even not a few who use modifications to the variables studied with the main variable being Jigsaw learning. For example, research (Abed et al., 2020) that predicts Jigsaw-type learning strategies on students' mathematics learning achievement. Furthermore, other data show that the Jigsaw model of learning geometric information is more effective than the lecture method (Timayi et al., 2015). Another study related to Jigsaw learning in Turkey states that there is an influence on students' abilities in natural science laboratory practice (Karacop, 2017).

Next, analyze category variables related to education level. Judging from the comparison of the magnitude of the effect size between Pre-School: Elementary: Junior High: High School: University (0.429: 2.924: 1.09: 0.942: 1.172), the research results show that the Jigsaw model of learning has a big influence from elementary to tertiary level, but not at the pre-school level. The

effect size of the implementation of the Jigsaw model at the pre-school level is in the small effect category because the model only influences the choice of learning goals in young children and encourages children to change their learning goals while doing the task (Leclercq et al., 2022). On the other hand, one of the research results showed a decrease in the average score during the four treatments using the Jigsaw model in social learning, although there was an average increase between the pre-test and post-test of 5% (Karta et al., 2021).

The findings also show that learning mathematics using the Jigsaw model is more effective at the elementary level than at other levels. According to research (Sulistiyowati & Astuti, 2020), the Jigsaw model of learning has a high level of cooperation as indicated by post-test and pre-test findings. This finding is in line with other research which states that the jigsaw model is an active learning model that has a higher level of social connectedness when Jigsaw type cooperative learning is used (Costouros, 2020). Other findings show that the Jigsaw model influences students' motivation in learning mathematics (Amin et al., 2020), mathematical representation abilities (Rambe et al., 2020), retention (Baken et al., 2020), collaboration abilities (Chang & Benson, 2020), and communication skills (Namaziandost et al., 2020). Although this is a contradiction where learning mathematics using the Jigsaw model at the high school level affects students' mathematical communication skills (Yeubun et al., 2020).

Learning mathematics using the Jigsaw model, as shown in Figure 6, also demonstrates that many research samples were collected at the secondary school level. This happens because the level of thinking has entered the formal stage. On the other hand, this learning triggers the psychology of students to be curious about their peers (Utami et al., 2021). In addition to their mathematical abilities, students' mathematical successes have beneficial consequences after the Jigsaw learning approach is implemented (Ribut, 2021). However, other studies on cooperative learning with the type of Think Pair Share aided by comics show that it is no better than not using comics to develop problem-solving skills (Turyanto et al., 2019). However, Pair Check cooperative learning has been shown to improve students' overall cooperative abilities (Wijayanti & Kusdiyanta, 2019).

In this study, sample size was also applied to categorical variables to clarify the size of the effect on the study. The findings showed that (31 or more) had a greater influence than other categories. This study also conducted an analysis of publication sources on categorical variables. Based on the findings, one literature was obtained from proceedings and 29 other literature was obtained from journals. These data imply that the study was free of publication bias, which is supported by trim and fill.

Many studies are not taken or do not fall into the required category while examining this research. Such research conducted by (Budiawan & Arsani, 2013) using the same variables but carried out on sports subjects. In addition, there are also some unqualified studies where there is a lack of pretest data as a control study. Of the 500 data collected, only about 30 studies were included in the requirements after several screenings. And obviously, it does not end there; this study needs to be researched further to determine its effectiveness.

## CONCLUSION

This research was conducted by taking articles from proceedings and international journals in the range of 2010 – 2023. A meta-analysis research with 30 samples revealed a fixed effect with an effect size of 1.146, indicating that mastering the Jigsaw technique had a significant impact on students' mathematical abilities. This means that Jigsaw learning is still relevant to improve students' mathematical skills. Furthermore, this study was conducted analysis based on category variables divided into four variables. Based on the analysis of education levels, it was discovered that the degree of the influence varied depending on the study. However, learning using the Jigsaw model is more influential at the elementary level than other levels. In addition, the number of samples in 31 or more has a higher effectiveness and also publication sources based on journals have more significant influence, meanwhile, analysis of country categories shows that there are no differences in the results of implementing the Jigsaw model for research in Indonesia or abroad.

In the world of education, the application of the Jigsaw model is quite effective, as proven by the findings of several studies, especially at the elementary school level, where students enjoy playing



and studying in groups, exchanging information, and working together to find information. This research has limitations because the samples in this research were obtained from Google Scholar using PoP software, which means that there are still many other research samples that were not carried out due to access or payment constraints. Recommendations for further research are to re-examine the same themes using the Scopus database, and compare the implementation of the Jigsaw model in mathematics learning with other models.

## CONFLICT OF INTEREST

There is no conflict of interest

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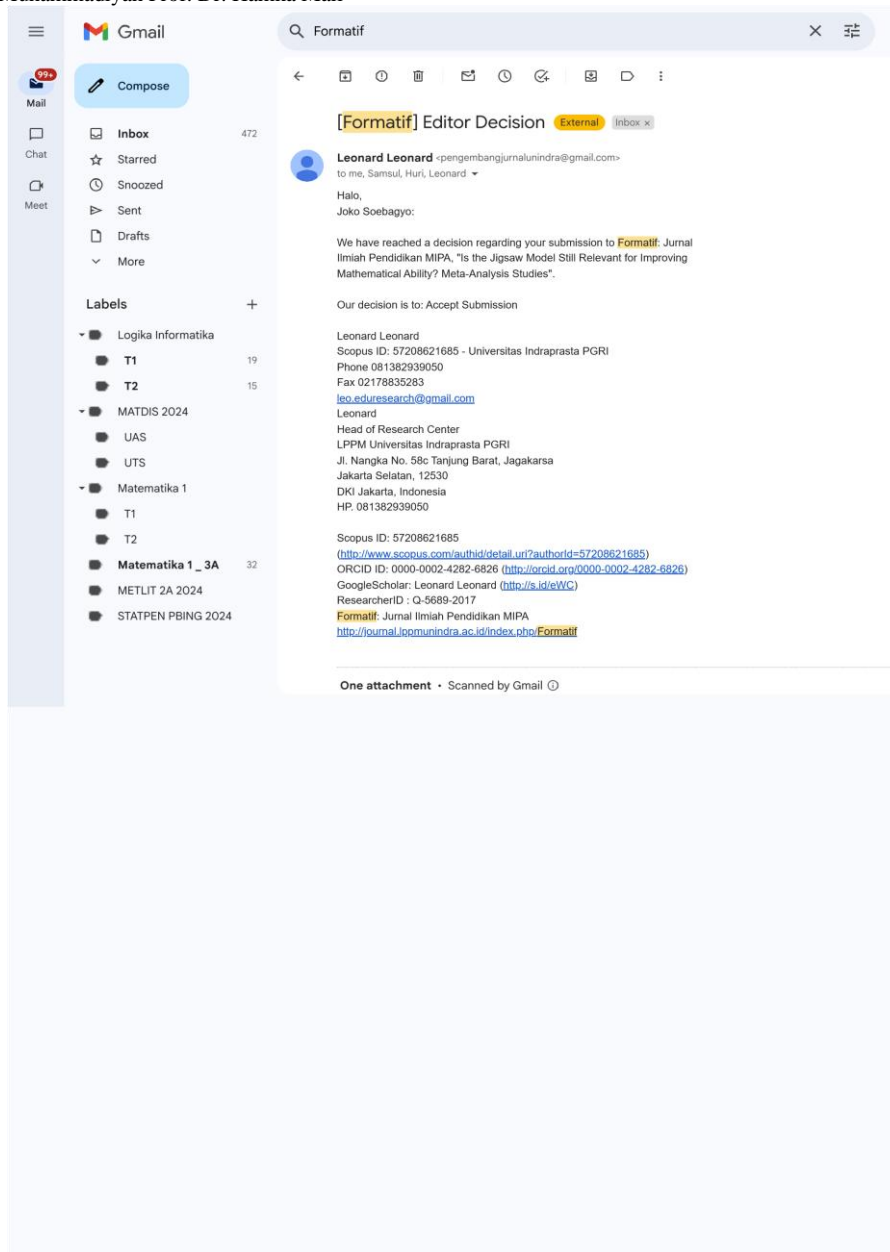
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Bio Statement —

## Title and Abstract

Title Is the Jigsaw Model Still Relevant for Improving Mathematical Ability? Meta-Analysis Studies

Abstract The Jigsaw learning model focuses on student activities in learning in general and also has an influence on students' mathematical abilities, but there are also some that do not have a significant influence.

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This research attempts to answer how much influence the Jigsaw model has based on the desired categorical variables. Therefore, meta-analysis research is needed to provide comprehensive and indepth conclusions about the application of the Jigsaw model to students' mathematical abilities. Comprehensive Meta-Analysis (CMA) is used to evaluate a property's value based on comparisons to similar properties in the same area. Data was obtained from Publish or Perish (PoP) with a total of 500 articles from 2010 to 2023 with the Google Scholar database. The number of journals that meet the requirements and will be analyzed is 30 sample articles with a total of 1252 students. The moderator variables in this study consider country, education level, sample size and publication source. Based on research findings, the Jigsaw model has a significant influence on numeracy skills (P-value 0.05), with an effect size of 1.146 which is classified as very high based on fixed effects and a standard error of 0.045. The research results show that the Jigsaw model is still relevant for improving students' mathematical abilities, especially at the elementary school level. This meta-analysis study reveals that there is no difference in the results of implementing the Jigsaw model on students' mathematical abilities in all country categories.

## Indexing

Academic discipline Mathematics Education; Pendidikan Matematika; Pembelajaran Matematika and sub-disciplines

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### KEYWORDS

Computer assisted learning media, integer arithmetic operations Contextual Teaching and Learning Discovery Blended Learning Self-efficacy, Learning Outcomes Elementary School, Mathematical Critical Thinking (MCT), Problem Based Learning (PBL), Interactive Learning Multimedia, Web, Basic Concepts of Science, ICT Interest Learning Media, Monopoly Mathematics, ADDIE Model Mathematical Connection Mathematical Problem-solving Ability, High Mathematical Disposition, Medium Mathematical Disposition, Low Mathematical Disposition Mathematical Anxiety, Correlation and Regression, Biology Education Meta Analysis Problem-Based Learning Psycholinguistics Cybernetic, human character, self-image, survey, questionnaire R & D (Research Development), E-Learning, Vocational School Students, Plomp Model Science Process Skill Self regulated thinking (SRT), math problems, thinking process Writing Skills STREAM, Teaching Materials, Preservice Science Teacher algebraic representation, calculus, conceptualization, domain function, e-Worksheets, Geogebra, Student Independent Learning e-comic, learning media, mathematics, 4-D Model mathematics education

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