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

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Abstract

The Jigsaw learning model focuses on student activities in general learning and influences students' mathematical abilities. Still, some do not have a significant influence. This research attempts to answer the question of how much impact the Jigsaw model has based on the desired categorical variables. Therefore, meta-analysis research is needed to provide comprehensive and in-depth conclusions about applying the Jigsaw model to students' mathematical abilities. Comprehensive Meta-Analysis (CMA) evaluates a property's value based on comparisons to similar properties in the same area. Using the Google Scholar database, data was obtained from Publish or Perish (PoP), which had 500 articles from 2010 to 2023. 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 are country, education level, sample size, and publication source. Based on research findings, the Jigsaw model significantly influences numeracy skills (P-value 0.05), with an effect size of 1.146, 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 no difference in the results of implementing the Jigsaw model on students' mathematical skills in all country categories.

Keywords: Jigsaw Model, Meta-Analysis, Mathematical Abilities

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INTRODUCTION

Recognize mathematics as an abstract science that is the basis for achieving other sciences. Mathematics complements all existing sciences, including science, technology, art, and many others (Kamarullah, 2017). The difficulty level in mathematics is often used as a benchmark in achieving success. No wonder many of the nation's students must be proficient in mathematics. Sometimes, the difficulty in solving abstract problems often decreases interest in learning, so you are too 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: 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). Understanding logic, of course, requires motivation and good learning and teaching. Not all teaching provided can make some students interested in learning. Therefore, as a good teacher, there needs to be variety in providing learning models. This variant ensures that learners grasp the topic and achieve learning objectives. Currently, many learning models are often found, ranging from Problem-Based Learning (PBL), Project Learning (PBjL), and Realistic Mathematics Education (RME) to Cooperative

Learning (CL). With the development of technology, much research is related to learning. There are 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 creates interaction between group members, and teachers try to condition it by motivating students to 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, who has responsibility for the material in the group, and the ability to master and teach the topic to the other group members (Lubis &. The initial and expert groups 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. At the same time, the expert group consists of members of different origin groups. It is tasked with researching and studying certain subjects while carrying out tasks that will be communicated to members of the origin group. Several specialists from the initial group have been combined to form the expert group. Being interconnected with each other, where each student can convey the information needed to their teammates so that the goal of solving problems can be achieved, is the key to the success of Jigsaw (Werdiningsih &. In this learning, students work in a team and are assigned to read and study a subject. Random selection is made for each group member 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 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 can apply 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. In discussion activities, students are grouped into specialist groups and origin teams to solve mathematical problems (Handayani, 2020).

To understand abstract science, students must be taught the ability to train in critical thinking (Sarman & Soebagyo, 2022). Critical thinking is the ability of human thinking to have systematic and logical steps (Saviraningrum & Soebagyo, 2022). Thinking logically means being precise, an essential skill for life, and working effectively in all areas of life. The advantage of critical thinking is that 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). Creative thinking skills should belong to everyone (Florentina & Leonard, 2017). No less important, the capacity to make mathematical connections is required to find relationships from a representation of concepts and procedures, to grasp between mathematical themes, and to apply mathematical concepts in other fields or daily life (Widarti, 2013).

The Jigsaw model, derived from research findings, assists students in understanding the findings they make (Sari & Fitriani, 2018). In other studies, there is an influence on students' mathematical ability, but there are also those that do not have a significant influence. Of course, there are different kinds of conclusions in various studies, even though the variables studied have similarities. Based on the existing problems, meta-analysis can provide comprehensive and in-depth conclusions on specific variables or topics that must be discussed. This study can answer the question of how much influence the Jigsaw model has based on the desired category variables. One of the research results showed a significant increase in students' mathematical abilities after attending Jigsaw model lectures with discussion assessments 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*. This analysis aimed to identify the magnitude of the influence on the Jigsaw model and investigate the impact of characteristics on mathematical ability in determining the variation in effect size of each available research. A meta-analysis approach is used to achieve this purpose. Meta-analysis compares primary studies with other scientific advancements by drawing statistical findings in effect size on quantitative data studies based on relevant themes (Rosdiana, 2021). The steps in compiling the meta-analysis start from (1) choosing the criteria for the article to be researched, (2) looking for literature sources related to relevant research to be used, (3) coding 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 searches. 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). As seen in Figure 1, it is obtained that the search process for applying the Jigsaw model on Google Scholar using the PoP application reaches 500 data.

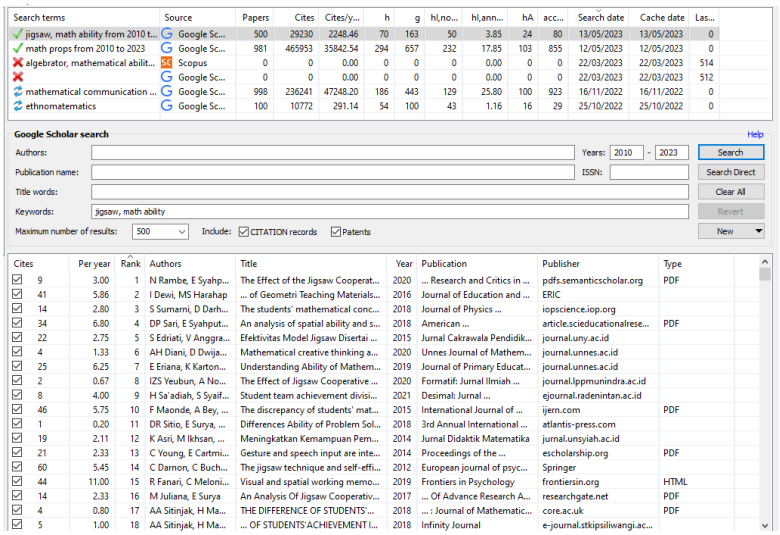

Figure 1. Google Scholar database search results (Jigsaw, Math ability)

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: (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. Moreover, journals or study criteria that do not match will be removed from the analysis data, and (3) learning to use a quantitative approach where there must be control groups and experiments in quantitative data. 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.

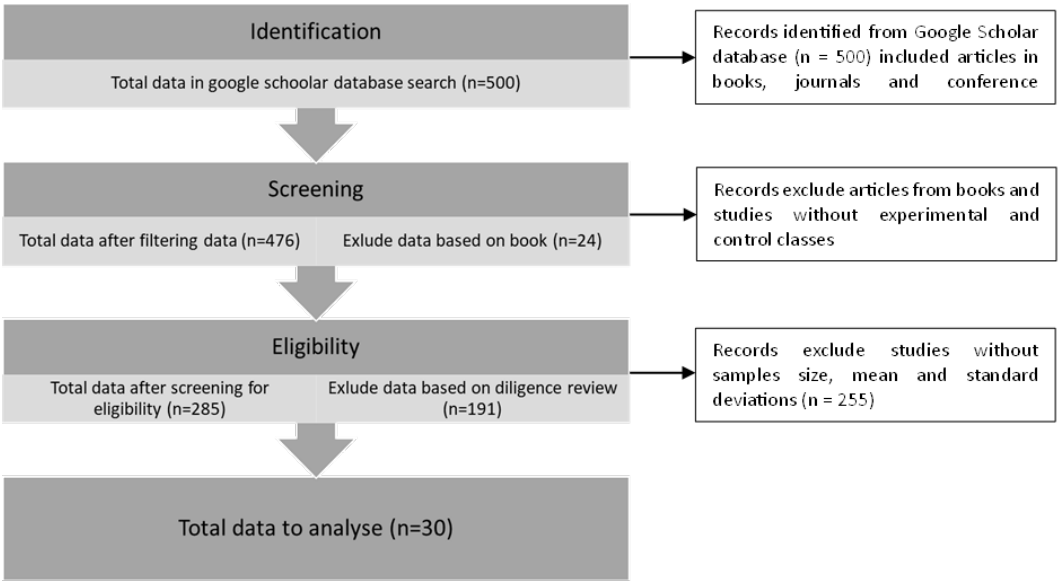

Figure 2. Filter data using PRISMA

Coding

All studies that match the criteria are coded manually using a detailed coding scheme based on protocols. This study's criteria were carried out using 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 three coders from one research group to determine reliability. Three coders received a copy of the article, the coding form, and the protocol. The following formula was used to calculate the percentage agreement (PA) to assess the reliability of this coder. In this scenario, N_A represents the total number of agreements, while N_P represents the entire number of disagreements.

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

Statistical Analysis

The data was evaluated with the CMA application, with particular attention paid to the effect size, 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. The side effect (δ) was classified as $\delta < 0.2$ (negligible), $0.2 \leq \delta < 0.5$ (small effect), $0.5 \leq \delta < 0.8$ (modesignificsignificante effect), $0.8 \leq \delta < 1.3$ (big effect), and $1.3 \leq \delta$ (huge effect) (Cohen et al., 2007). The random effect technique was chosen as the estimation method since no assumption exists that all research has 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 affect study effect sizes differently.

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

RESULTS & DISCUSSION

Results

Literature Search Results

This study aimed to determine whether the magnitude of the effect created affected 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 is that researchers use vulnerable research time in 2010 – 2023. Furthermore, the second criterion researchers used was jigsaw and math ability, and the

maximum number of results was limited to 500 documents. Five hundred articles were collected from the topics used, with 24 data from books and the rest from journals and conference proceedings.

Literature Selection Results

After setting the criteria for the 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 sample size, mean, and standard deviations. This statistical data aims to calculate the effect size 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 criteria results in this study focused on vulnerable years 2010 - 2023. The selection of criteria for this year's vulnerability was conducted to ensure the available research was 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 considered 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 and 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 names of the studies identified. Furthermore, the magnitude of the effect, which contains the results of the intervention, is shown. It can be seen that 1 data 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 data to see discrepancies in the source of findings from the study.

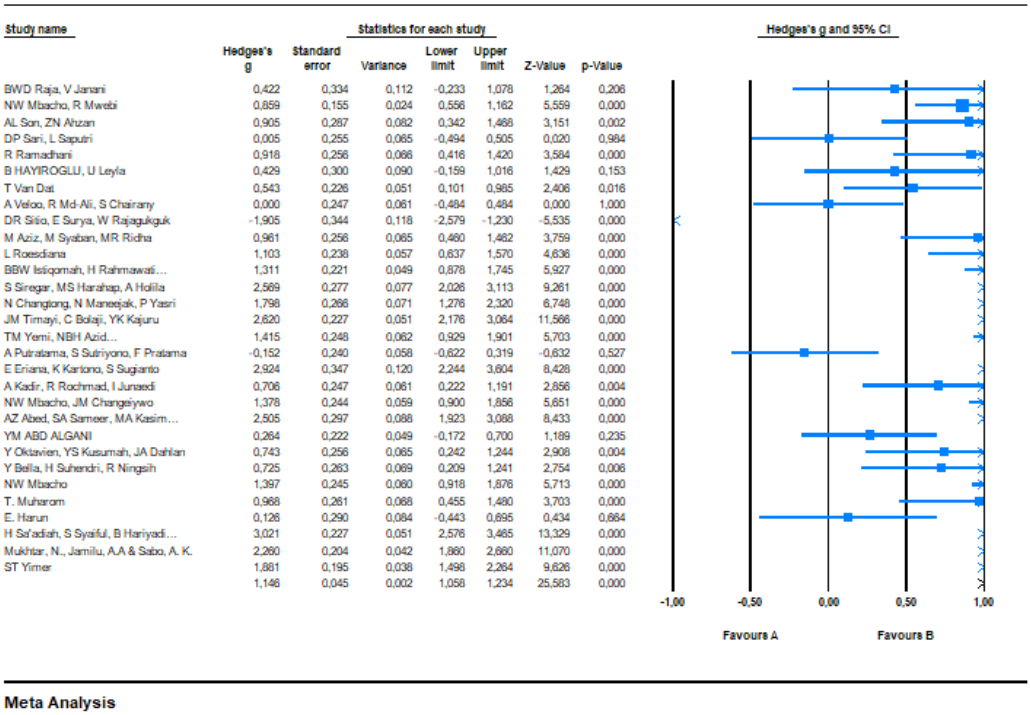

Figure 3. Research Forest Plot

According to Figure 3, the response rate is inconsistent. The research is likely to be diverse. As a result, the starting assumptions must be statistically examined to be 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 4. 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 conferences 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 high effect size of 1.146 was used. They use a null test of 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 significantly impacts mathematical ability.

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 in the influence of publication bias. In addition, trim and fill were performed to estimate potentially missing studies due to publication bias.

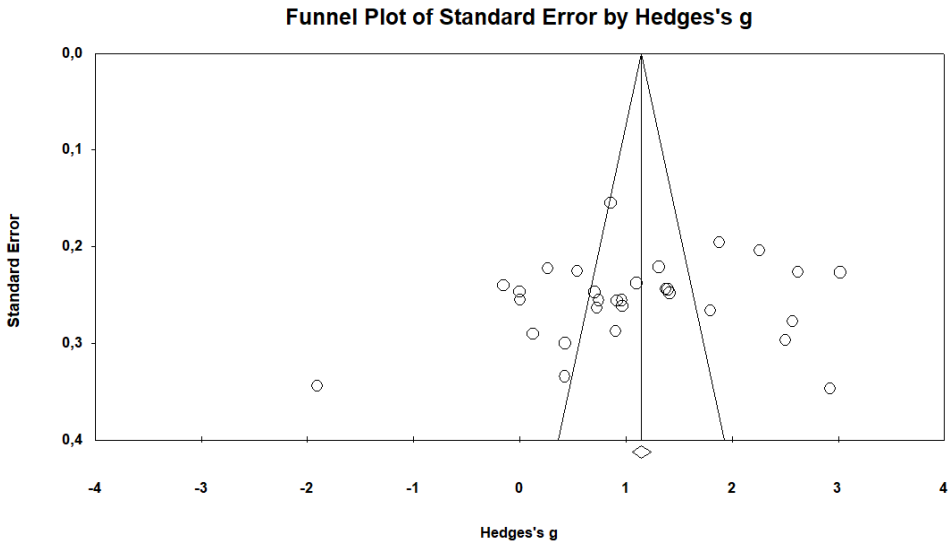

Figure 5. Funnel plot of 30 samples

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 6. Trim and Fill

The findings of trim and fill in Figure 5 indicate 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, which is a very high value for 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 each study's effect sizes vary, 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.

Country

The effect size in the 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.

No	Variabel Moderator	Group	N	Combined Effect Size (Hedge's g)	Test of null (2-Tail)		Heterogeneity			
					Z	P-value	Between-Classes Effect (Q-value)	Df (Q)	P-value	Decision
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				
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
		Prociding	1	2.26	11.07	0.000				

Figure 7. Summary of Category Variable Analysis

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 applying 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 $p < 0.05$. This situation suggests that the sample size influences the 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. To 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 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 and abroad, this research has been carried out a lot, even not a few who use modifications to the variables studied, with the primary variable being Jigsaw learning. For example, research (Abed et al., 2020) 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 it influences students' abilities in natural science laboratory practice (Karacop, 2017).

Next, the category variables related to education level will be analyzed. Judging from the comparison of the magnitude of the effect size between preschool, Elementary, Junior High, High School, and University (0.429: 2.924: 1.09: 0.942: 1.172), the research results show that the Jigsaw model of learning has a significant 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 preschool 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 (Sulistyowati & Astuti, 2020), the Jigsaw learning model has a high level of cooperation, as indicated by post-test and pre-test findings. This finding aligns with other research, which states that the jigsaw model is an active learning model with a higher level of social connectedness when using jigsaw-type cooperative learning (Costouros, 2020). Other findings show that the Jigsaw model influences students' motivation to learn 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). However, this is a contradiction, as 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 implementing the Jigsaw learning approach (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 improved 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 more significant influence than other categories. This study also analyzed publication sources on categorical variables. Based on the findings, one piece of literature was obtained from proceedings, and 29 others were obtained from journals. These data imply that the study was free of publication bias, supported by trim and fill.

Many studies have not been taken or do not fall into the required category while examining this research. Such research was conducted by (Budiawan and 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. It does not end there; this study needs further research to determine its effectiveness.

CONCLUSION

This research used articles from proceedings and international journals from 2010 – 2023. Meta-analysis research with 30 samples revealed a fixed effect with an effect size of 1.146, indicating that mastering the Jigsaw technique significantly impacted students' mathematical abilities. This means that jigsaw learning is still relevant in improving students' mathematical skills. Furthermore, this study conducted an analysis based on category variables divided into four variables. Based on the analysis of education levels, it was discovered that the degree of influence varied depending on the study. However, learning using the Jigsaw model is more influential at the elementary level than at other levels. In addition, the number of samples in 31 or more has a higher effectiveness, and publication sources based on journals have a more significant influence. Meanwhile, analysis of country categories shows no differences in the results of implementing the Jigsaw model for research in Indonesia or abroad. In the world of education, applying the Jigsaw model is quite adequate, 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 were obtained from Google Scholar using PoP software, which means 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.

REFERENCES

Abed, A. Z., Sameer, S. A., Kasim, M. A., & Othman, A. T. (2020). Predicting the effect of implementing the jigsaw strategy on students' academic achievement in mathematics classes. *International Electronic Journal of Mathematics Education*, *15*(1), 1–7. https://doi.org/10.29333/iejme/5940

Amin, M., Nur, F., Diah, M., Damayanti, E., & Harti, S. (2020). The influence of jigsaw-type cooperative learning model on students' mathematics learning outcomes and motivation. *Desimal: Jurnal Matematika*, *3*(3), 235–246. https://doi.org/10.24042/djm.v3i3.6831

Baken, E. K., Adams, D. C., & Rentz, M. S. (2020). Jigsaw method improves learning and retention for observation-based undergraduate biology laboratory activities ABSTRACT. *Journal of Biological Education*, *00*(00), 1–6. https://doi.org/10.1080/00219266.2020.1796757

Budiawan, M., & Arsani, N. L. K. A. (2013). Pengaruh model pembelajaran kooperatif tipe jigsaw dan motivasi belajar terhadap prestasi belajar ilmu fisiologi olahraga. *Pendidikan Indonesia*, *2*(1), 138–144. https://doi.org/10.3102/0013189X18785613

Chang, W. L., & Benson, V. (2020). Jigsaw teaching method for collaboration on cloud platforms. *Innovations in Education and Teaching International*, *00*(00), 1–13. https://doi.org/10.1080/14703297.2020.1792332

Cohen, L., Manion, L., & Morrison, K. (2007). Book reviews research methods in education. *The Austr Alian Educational Researcher*, pp. *2*, 147–156.

Cohen, L., Manion, L., & Morrison, K. (2018). Research methods in education. In *Jurnal Penelitian Pendidikan Guru Sekolah Dasar* (Vol. 6, Issue August).

Cooper, H., Hedges, L. V., & Valentine, J. C. (2009). Handbook of research synthesis and meta-analysis 2nd Edition. In *The Lancet* (Vol. 389, Issue 10082).

Costouros, T. (2020). Jigsaw Cooperative Learning Versus Traditional Lectures : Impact on student grades and learning experience. *Teaching & Learning Inquiry*, *8*(1), 154–172.

Edriati, S., Anggraini, V., & Siska, M. (2015). Efektivitas model jigsaw disertai penilaian diskusi untuk meningkatkan kemampuan matematis mahasiswa. *Jurnal Cakrawala Pendidikan*, *2*(2), 288–295. https://doi.org/10.21831/cp.v2i2.4833

Eryanti, I., & Soebagyo, J. (2021). Bibliometric analysis of blended learning mathematics in scientific publications indexed by Scopus. *Numerical: Jurnal Matematika Dan Pendidikan Matematika*, 91–102.

Florentina, N., & Leonard, L. (2017). Pengaruh model pembelajaran kooperatif terhadap kemampuan berpikir kreatif matematis siswa. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *7*(2), 96–106. https://doi.org/10.30998/formatif.v7i2.1877

Handayani, H. (2020). Pengaruh implementasi pembelajaran kooperatif tipe jigsaw terhadap kemampuan berpikir kritis matematis siswa sekolah dasar. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *5*(1), 50–60. https://doi.org/10.23969/jp.v5i1.1944

Haniyah, D., & Soebagyo, J. (2021). Analisis bibliometrik terhadap kemampuan komunikasi matematis dalam pembelajaran matematika berdasarkan perbedaan gender berbasis VOSViewer. *Buana Matematika: Jurnal Ilmiah Matematika Dan Pendidikan Matematika*, *11*(2), 121–136.

Hibattulloh, N., & Sofyan, D. (2014). Perbandingan kemampuan komunikasi matematis siswa antara yang menggunakan model pembelajaran kooperatif tipe jigsaw dengan konvensional (studi quasi eksperimen di kelas VII SMP Negeri 2 Bayongbong). *Jurnal Pendidikan Matematika*, *3*(3), 169–178.

Jaelani, A. (2015). Pembelajaran kooperatif, sebagai salah satu model pembelajaran di madrasah ibtidaiyya (MI). *Al Ibtida: Jurnal Pendidikan Guru MI*, *2*(1), 1–16. https://doi.org/10.24235/al.ibtida.snj.v2i1.189

Kamarullah, K. (2017). Pendidikan matematika di sekolah kita. *Al Khawarizmi: Jurnal Pendidikan Dan Pembelajaran Matematika*, *1*(1), 21. https://doi.org/http://dx.doi.org/10.22373/jppm.v1i1.1729

Karacop, A. (2017). The effects of using jigsaw method based on cooperative learning model in the undergraduate science laboratory practices. *Universal Journal of Educational Research*, *5*(3), 420–434. https://doi.org/10.13189/ujer.2017.050314

Karta, I. W., Rachmayani, I., & Rasmini, N. W. (2021). The influence of cooperative learning through authentic assessment-based jigsaw on the social development of early childhood. *JPI (Jurnal Pendidikan Indonesia)*, *10*(4), 633–642. https://doi.org/10.23887/jpi-undiksha.v10i4.34353

Leclercq, M., Gimenes, G., Maintenant, C., & Clerc, J. (2022). Goal choice in preschoolers is influenced by context, cognitive flexibility, and metacognition. *Frontiers in Psychology*, *13*(February), 1–19. https://doi.org/10.3389/fpsyg.2022.1063566

Lubis, N. A., & Harahap, H. (2016). Pembelajaran kooperatif tipe jigsaw. *Jurnal As-Salam*, *1*(1), 96–102.

Maarif, S., Wahyudin, W., Noto, M. S., Hidayat, W., & Mulyono, H. (2018). Geometry exploration activities assisted with dynamic geometry software (Dgs) in a teacher education classroom. *Infinity Journal*, *7*(2), 133. https://doi.org/10.22460/infinity.v7i2.p133-146

Musna, R. R., Juandi, D., & Jupri, A. (2021). A meta-analysis study of the effect of the Problem-Based Learning model on students' mathematical problem-solving skills. *Journal of Physics: Conference Series*, *1882*(1), 2–8. https://doi.org/10.1088/1742-6596/1882/1/012090

Namaziandost, E., Gilakjani, A. P., & Hidayatullah. (2020). Enhancing pre-intermediate EFL learners' reading comprehension through the use of Jigsaw technique. *Cogent Arts and Humanities*, *7*(1). https://doi.org/10.1080/23311983.2020.1738833

Nurfitriyanti, M. (2017). Pengaruh model pembelajaran kooperatif tipe jigsaw terhadap hasil belajar matematika ditinjau dari kecerdasan emosional maya. *Jurnal Formatif*, *7*(2), 153–162. https://doi.org/10.31949/jcp.v8i4.2941

Poerwati, C. E., Suryaningsih, N. M. A., & Cahaya, I. M. E. (2020). Model pembelajaran kooperatif tipe jigsaw II dalam meningkatkan kemampuan matematika anak. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *5*(1), 281. https://doi.org/10.31004/obsesi.v5i1.496

Rambe, N., Syahputra, E., & Elvis, E. (2020). The effect of the jigsaw cooperative learning model and the student's initial mathematical abilities and its effect on the mathematical representation ability and learning motivation of students in the PAB 10 Sampali Private Elementary School. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, *3*(3), 1591–1599. https://doi.org/10.33258/birle.v3i3.1249

Retnawati, H., Apino, E., Kartianom, Djidu, H., & Anazifa, R. D. (2018). *Pengantar Analisis Meta* (Issue July).

Ribut, O. Y. P. (2021). Model pembelajaran kooperatif jigsaw pada prestasi matematika siswa sekolah menengah pertama. *Jurnal Jendela Pendidikan*, *1*(02), 61–65. https://doi.org/10.57008/jjp.v1i02.9

Rosdiana, R. (2021). *Studi Meta - Analisis Penggunaan Model Pembelajaran Kooperatif Terhadap Kemampuan Komunikasi Matematis Siswa*.

Saputra, G. A. A., Agung, A. A. G., & Suwatra, I. W. (2017). Pengembangan multimedia interaktif sebagai suplemen pembelajaran kooperatif tipe stad pada mata pelajaran ips kelas Viii Smp. *Jurnal Edutech Undiksha*, *05*(1), 121–131.

Sari, S. R., & Fitriani, D. (2018). Meningkatkan komunikasi matematis melalui model pembelajaran kooperatif tipe jigsaw. *Journal for Research in Mathematics Learning*, *1*(1), 183–188. https://doi.org/10.30605/pedagogy.v7i1.1801

Sarman, S. N., & Soebagyo, J. (2022). Analisis bibliometrik terhadap kemampuan berpikir kritis matematika berdasarkan pemecahan masalah berbasis VOS viewer. *Vygotsky: Jurnal Pendidikan Matematika Dan Matematika*, *4*(2), 117–128.

Saviraningrum, W., & Soebagyo, J. (2022). Analisis bibliometrik dengan kata kunci mathematical critical thinking student independent menggunakan VOSviewer. *JKPM (Jurnal Kajian Pendidikan Matematika)*, *8*(1), 1. https://doi.org/10.30998/jkpm.v8i1.13529

Siswono, T. Y. E. (2014). Permasalahan pembelajaran matematika dan upaya mengatasinya. *FMIPA UNESA*, 1–9.

Sukmawati, A. (2020). Meta analisis model problem based learning dalam meningkatkan kemampuan berpikir kritis pada pembelajaran matematika. *Thinking Skills and Creativity Journal*, *3*(2), 63–68. https://doi.org/10.23887/tscj.v3i2.30211

Sulistyowati, D. P., & Astuti, S. (2020). Efektivitas model pembelajaran kooperatif tipe jigsaw dan student teams achievement divisions (STAD) ditinjau dari keterampilan kerjasama pada mata pelajaran matematika siswa kelas 5 SD. *Jurnal Karya Pendidikan Matematika*, *7*(1), 92. https://doi.org/10.26714/jkpm.7.1.2020.92-103

Sumarmo, U. (2012). Pendidikan karakter serta pengembangan berfikir dan disposisi matematik dalam pembelajaran matematika. *Seminar Pendidikan Matematika*, 1–26.

Tamur, M., Subaryo, S., Ramda, A. H., Nurjaman, A., Fedi, S., & Hamu, A. (2021). Pengaruh pembelajaran kooperatif tipe jigsaw terhadap kemampuan berpikir kritis siswa SMP. *Journal of Honai Math*, *4*(2), 173–182. https://doi.org/10.30862/jhm.v4i2.201

Timayi, J. M., Bolaji, C., & Kajuru, Y. K. (2015). Effects of jigsaw IV cooperative learning strategy (J4CLS) on academic performance of secondary school students in geometry. *International Journal of Mathematics Trends and Technology*, *28*(1), 12–18. https://doi.org/10.14445/22315373/ijmtt-v28p504

Turyanto, T., Agustito, D., & Widodo, S. A. (2019). Think pair share with comic for mathematical problem-solving skills. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *9*(3), 181–190. https://doi.org/10.30998/formatif.v9i3.3773

Utami, P., Kadir, & Herlanti, Y. (2021). Meta-analisis pembelajaran kooperatif di indonesia. *Jurnal Inovasi Pendidikan IPA*, *7*(1), 106–115. https://doi.org/10.21831/jipi.v7i1.39574

Wardani, D. T. (2015). Pengaruh pembelajaran kooperatif tipe STAD (student teams achievement divisions) dan jigsaw terhadap prestasi belajar ekonomi ditinjau dari motivasi belajar siswa tahun ajaran 2014/2015. *EQUILIBRIUM : Jurnal Ilmiah Ekonomi Dan Pembelajarannya*, *3*(2), 105–111. https://doi.org/10.25273/equilibrium.v3i2.657

Werdiningsih, E., & Mukhlishin, M. I. (2021). Penerapan model pembelajaran kooperatif tipe jigsaw di kelas. *Jurnal Pendidikan Berkarakter*, *4*(2), 60–65.

Widarti, A. (2013). "kemampuan koneksi matematis dalam menyelesaikan masalah kontekstual ditinjau dari kemampuan matematis siswa" (jurnal STKIP jombang, 2012). *Jurnal Pendidikan Matematika*, *1*(003), 1–2.

Widyastuti, E. (2015). Peningkatan kemampuan pemahaman konsep dan komunikasi matematis siswa dengan menggunakan pembelajaran kooperatif jigsaw. *Journal of Mathematics Education*, *1*(1), 1–14.

Wijayanti, A., & Kusdiyanta, A. (2019). Cooperative skills improvement through mind mapping assisted pair check peningkatan keterampilan kooperatif melalui pair check berbantuan mind mapping. *Jurnal Ilmiah Pendidikan MIPA*, *9*(3), 257–266. https://doi.org/10.30998/formatif.v9i3.2927

Yayuk, E., Purwanto, As'Ari, A. R., & Subanji. (2020). Primary school students' creative thinking skills in mathematics problem-solving. *European Journal of Educational Research*, *9*(3), 1281–1295. https://doi.org/10.12973/eu-jer.9.3.1281

Yeubun, I. Z. S., Noornia, A., & Ambarwati, L. (2020). The effect of jigsaw cooperative learning methods on mathematical communication ability is viewed based on student personality. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *9*(4), 333–338. https://doi.org/10.30998/formatif.v9i4.4132

Zuhasni, N. (2022). *Penerapan Model Jigsaw untuk Meningkatkan Kemampuan Berpikir Kritis dan Hasil Belajar Siswa Kelas V SDN 2 Celala Aceh Tengah*.