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META-ANALYSIS: THE EFFECTIVENESS OF THE RECIPROCAL TEACHING MODEL ON STUDENTS' MATHEMATICS LEARNING OUTCOMES

Harun Onesimus Laia[1*], Dadan Dasari[2]
[1,2]Departement of Mathematics Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia
*Correspondence: harun.onesimus@upi.edu

ABSTRACT
One learning approach that can be applied to learning mathematics is reciprocal teaching because it is efficient in helping students become independent learners and developing students' courage in expressing opinions. Many studies have discussed Reciprocal Teaching with mathematics learning outcomes in primary and secondary schools with different conclusions. This study aimed to determine the effect of the Reciprocal Teaching model on students' mathematics learning outcomes. This study used a meta-analysis, a statistical analysis method that synthesizes data from several studies to obtain stronger findings. The sample in this study were articles that met the inclusion criteria and obtained as many as 8 articles. Data were analyzed using JASP V-0.18 software. The results showed that the Reciprocal Teaching model affected students' mathematics learning outcomes, with an effect size of 1.07 and a high effect size category. However, this analysis did not include some related studies because they did not meet the inclusion criteria. Therefore, further research using a larger sample size and a wider variety of studies is needed to gain a more thorough understanding.
Keywords: Maths Learning Outcomes, Meta-Analysis, Reciprocal Teaching

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PRELIMINARY

Learning mathematics is important in developing students' critical thinking and problem-solving skills. The quality of mathematics learning is often measured through student learning outcomes, which include concept understanding, ability to apply knowledge, and analytical skills. However, educational learning outcomes still show gaps and challenges that must be addressed. (Handayani & Hidayat, 2019). For this reason, educators must also take a role in overcoming this condition by taking the role of an educator who can help students improve their understanding and results. Laia (2023) argues that educators must keep up with the times to become actors in the progress of education. One of the ways to overcome low learning outcomes in mathematics is to innovate or change mathematics learning (Sapoetra & Hardini, 2020).

Learning innovations that can help teachers and students in learning are one of the learning methods. Pradja & Firmansyah (2020) argued that learning methods can help teachers so that students participate and are active in learning activities if the learning method is interesting. The quality of learning and student learning outcomes can be influenced or improved through the learning model applied by the teacher when teaching (Nandang et al., 2020). Therefore, innovation in learning methods is needed to improve the effectiveness of learning mathematics.

One method that has attracted significant attention is Reciprocal Teaching. This learning strategy actively involves students in the teaching and learning process by asking them to take turns discussing in small groups. Reciprocal Teaching is a constructivist approach that aims to help students understand learning material thoroughly by focusing on four key strategies: summarising, questioning, clarifying, and predicting. These strategies increase students' understanding and engagement with the material learned (Afdhal, 2015; Muanifah et al., 2021). In this Reciprocal Teaching learning, students become more enthusiastic and active in learning mathematics. According to Afdhal (2015), using reciprocal teaching in learning can increase students' enthusiasm for mathematics because learning activities are dynamic, and students are actively involved during the learning process. In this method, students act as "teachers," while the actual teacher acts as a model, facilitator, and guide who provides scaffolding.

The Reciprocal Teaching model has attracted significant attention in education because of its unique approach to encouraging independent learning. Ammy (2022) asserts that Reciprocal Teaching is an efficient way to help students become independent learners who can learn without the constant presence of the teacher, and this approach develops students' courage to express their point of view or opinion and trains students to find new ideas from what has been learned. Reciprocal Teaching makes students more independent in learning and more accessible to think independently or together (Sadiyono, 2014). Based on the description above, it can be concluded that reciprocal teaching can be influential in improving students' understanding and engagement, increasing their enthusiasm and active participation in learning, and fostering their independence and courage in expressing opinions. This highlights the importance of the Reciprocal Teaching model in the educational environment, making it an exemplary method for educators who aim to develop more independent and proactive students.

Reciprocal Teaching is a learning model that has been widely researched because of its potential to improve student learning outcomes. This model can be applied at various levels of education, from elementary to high school, and can be adapted to various subjects, making it a versatile tool for educators to improve their teaching practices. Several studies have shown that Reciprocal Teaching can improve student learning outcomes, especially regarding reading comprehension and other subjects (Hutauruk et al., 2021; Sundahry & Putra, 2020). Likewise, in mathematics learning, many studies discuss Reciprocal Teaching with mathematics learning outcomes in both primary and secondary schools. Several research results discussing Reciprocal Teaching with mathematics learning outcomes show a significant increase in students' mathematics learning outcomes (Ammy, 2022; Mulyono & Elly S., 2020; Pradja & Firmansyah, 2020). However, there is also research that shows more varied results, depending on independence and implementation (L. Hidayah et al., 2019), as well as research that shows there is no influence of the Reciprocal Teaching model on mathematics learning outcomes (Noorliani & Kusumawati, 2013). This diversity of results also leads educational researchers and practitioners to explore further the specific conditions under which Reciprocal Teaching may be most effective or require modification to increase its effectiveness in different learning environments. This difference in results also highlights the importance of conducting a meta-analysis to identify the influence of Reciprocal Teaching on overall mathematics learning outcomes.

Meta-analysis is a powerful method for demonstrating the effectiveness of various educational interventions, including learning models. With meta-analysis, researchers can combine the results of various relevant studies to get a general picture of the impact of an intervention. Meta-analysis is considered an objective approach in conducting literature observations because it is a technique that can be used to assess the significance of previous similar research using effect size (Tamur et al., 2020). Thus, this approach allows researchers to see more clearly the effectiveness of a learning model, such as Reciprocal Teaching, and provides a more comprehensive view of its contribution to student learning outcomes.

In addition, this meta-analysis will also consider the quality of the research involved, such as research design, sample size, and data analysis methods. Thus, the results of this meta-analysis are expected to provide a more accurate and reliable estimate of the effect of reciprocal teaching on mathematics learning outcomes.

This research was conducted using a meta-analysis of literature on the influence of Reciprocal Teaching on mathematics learning outcomes. It is hoped that the findings of this research can provide more appropriate direction for educators and decision-makers in choosing efficient teaching strategies to improve student learning outcomes in mathematics.

Based on the description above, this research aims to use meta-analysis to investigate the influence of the Reciprocal Teaching model on students' overall mathematics learning outcomes.

This research also aims to provide empirical evidence regarding the effectiveness of Reciprocal Teaching and practical recommendations for educators. Through this research, we hope to contribute positively to improving the quality of mathematics learning at various levels of education. In this way, students can achieve better learning outcomes and be able to face more complex challenges in the future.

METHOD

This research uses meta-analysis to evaluate and collect findings from various studies relevant to the selected topic. A statistical method called meta-analysis synthesizes data from several studies to obtain more robust and widely applicable findings. Retnawati et al. (2018), suggested that meta-analysis is a quantitative research strategy that involves analyzing quantitative data from previous studies or using data from other existing studies to confirm or refute the hypotheses proposed in these studies. Meta-analysis synthesizes quantitative results from a sample of studies and implicitly generalizes them to all relevant studies conducted on an issue (Pigott & Polanin, 2019).

In this research, the data that has been obtained from data collection will be processed systematically and used to make statistical conclusions. The conclusions obtained state the size or magnitude of the relationship between the variables studied. The measure used to reflect the magnitude of the relationship between these variables is known as effect size, which is an important indicator in statistical analysis to describe how strong or significant the relationship between the variables studied is. Effect size is a very important quantitative measure because it is used to summarise the findings in a meta-analysis of research. By using effect size, we can get a clearer and more measurable picture of the extent to which a variable affects other variables. Retnawati et al. (2018) explain that effect size is a quantitative measure used to summarise findings in meta-analysis research.

A critical step in this process is establishing inclusion criteria, which determines which articles or studies are worthy of inclusion in the analysis. Inclusion criteria were designed to ensure that the samples taken were relevant and of sufficient quality to answer the research questions. Based on the predetermined inclusion criteria, the samples in this study were taken from several published articles that met the requirements. Inclusion criteria in this study include 1) articles published in 2015-2024; 2) articles published in journals or proceedings; 3) research locations in Indonesia as well as elementary, middle, and high school students; 4) articles that use experimental or quasi-experimental research methods (using experimental and control classes); 5) articles that have statistical data information (average value, sample size, standard deviation value); 6) the theme of the article which is the focus of the research is the influence of the Reciprocal Teaching model on students' mathematics learning outcomes; 7) accessible articles. By applying these inclusion criteria, the research results are hoped to reflect the actual situation and provide accurate and reliable conclusions.

In this study, data was collected by searching previous studies regarding Reciprocal Teaching and student mathematics learning outcomes online using Publish or Perish software. The keywords used in the search were adapted to the research topic and included various synonyms and related terms. The keywords used are "Reciprocal Teaching" and "Mathematics Learning Outcomes". After searching, 65 relevant articles were obtained. Then these articles were first selected based on their titles and abstracts to determine their relevance to the research topic. After this initial selection, a full selection was carried out on articles that passed the first stage, ensuring that each article complied with the inclusion criteria established in this study. This selection process aims to ensure that only articles that meet all inclusion requirements will be used in further analysis to produce good results.

The collected data was analyzed using statistical software, namely JASP V-0.18. The analysis was carried out using Hedge's g formula to assess the magnitude of the influence of the Reciprocal Teaching model on mathematics learning outcomes. Hedge's g values are categorized into 5 groups (Thalheimer & Cook, 2002), as shown in table 1.

Table 1. Effect Size Categories

Range of Effect Size (ES)	**Interpretation**
$-0.15 \leq ES < 0.15$	Ignored
$0.15 \leq ES < 0.40$	Low
$0.40 \leq ES < 0.75$	Medium
$0.75 \leq ES < 1.10$	High
$1.10 \leq ES < 1.45$	Very High
$ES \geq 1.45$	Very Good

The statistical analysis that is first carried out is to carry out a publication bias test by ensuring that the effect size distribution of several research samples or primary studies identified is free from publication bias so that further tests can be carried out. In any research, maintaining the validity of the results is essential, especially in meta-analysis studies that collect and analyze data from various sources. One of the main threats to this validity is publication bias. Publication bias occurs when research results with significant or positive findings are more likely to be published than results that are not significant or negative. This may result in some findings overrepresenting the meta-analysis data set, providing an inaccurate picture of the effect. As stated by Nakagawa et al. (2022), publication bias can threaten the validity of quantitative evidence from meta-analyses and needs to be alerted by researchers.

After determining the effect size for each study and publication bias, the next step is to carry out a heterogeneity test by checking the Q-statistic and p-value. This test not only determines the appropriate estimation model but is also carried out to summarize the effect size of all sample articles collected. The interpretation of the test is that if the p-value < 0.05, then the effect size of each sample is considered homogeneous so that the estimation model used is a fixed effect model and vice versa; if the p-value is > 0.05, the effect size of each sample is considered heterogeneous so that The estimation model used is the random effect model (Retnawati et al., 2018).

The next step that will be taken in the process of analyzing this research is to conduct hypothesis testing using Z statistics calculated based on Hedges's g equation. This hypothesis test is used to determine whether there is a significant effect of the Reciprocal Teaching model on students' mathematics learning outcomes. For the interpretation of the test results, if the Z statistical value shows a significant result or p-value <0.05, then we can conclude that the application of the Reciprocal Teaching model has a significant effect on improving students' mathematics learning outcomes. Conversely, suppose the Z statistical value does not show significant results or p-value > 0.05. In that case, we cannot conclude that there is a significant effect of the Reciprocal Teaching model on students' mathematics learning outcomes.

RESULT AND DISCUSSION

In the article selection process, an article search was first conducted using the keywords "Reciprocal Teaching" and "Mathematics Learning Outcomes" and 65 articles were obtained. Furthermore, from the 65 articles, an initial screening was carried out by reviewing the titles and abstracts, which eliminated 18 articles, leaving 47 articles. From the remaining 47 articles, a further selection process was carried out based on the predetermined inclusion criteria. This process eliminated 39 articles for various reasons such as not being scientific articles, inaccessible articles, incomplete data, wrong population, and inappropriate study design. After conducting a selection process based on previously determined inclusion criteria, 8 articles were obtained that met the requirements for further analysis. Of the 8 articles that have been selected and meet these requirements, it is known that all of the research was conducted on junior high school students. These selected articles include various studies that examine the influence of the Reciprocal Teaching model on student mathematics learning outcomes. Figure 1 presents a prism diagram that visually shows the entire selection process of the obtained articles. This diagram provides a clear picture of the selection stages that have been passed until finally articles are obtained that meet the criteria for analysis in this research.

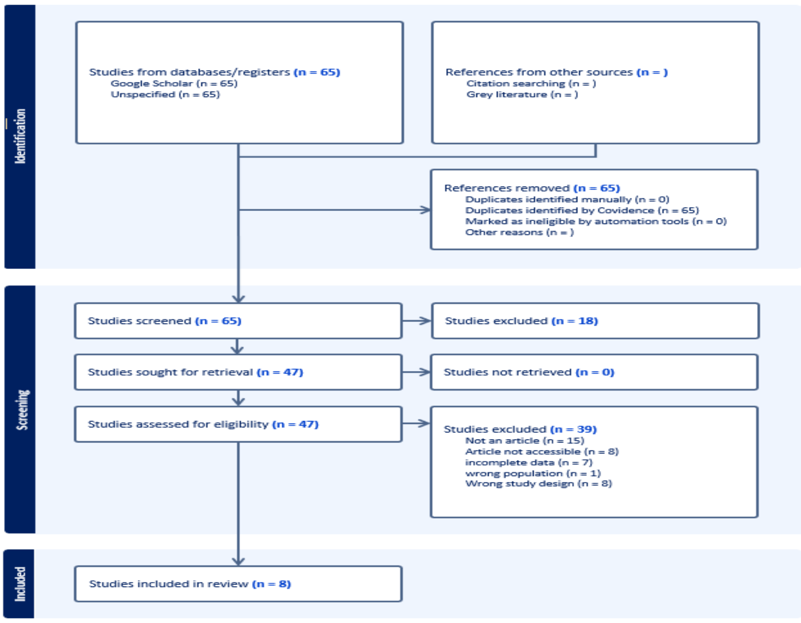

Figure 1. Prism Diagram

After the selection process, several articles to be analyzed are coded. Then data extraction is carried out based on statistical data which includes the number of samples, mean value, and standard deviation of the experimental group treated with the Reciprocal Reaching model and the control group treated with conventional learning. Table 2 shows articles from the selection process and statistical data to be analyzed.

Table. 2 Article Data/Research Samples and Statistical Data

Sample	Author	Experimental Group			Control Group		
		N	Mean	SD	N	Mean	SD
A1	Sitti Sastriana Bada & La Misu, (2015)	24	77,1	6,8	26	69,6	4,85
A2	Risqhi Febriani & Drs. Prayogo, (2017)	35	83,1	7,77	34	72,1	8,88

A3	Rianita Simamora, (2017)	35	18	2,53	31	15	2,2
A4	Rina Ika Wahyuni, (2017)	22	66,8	22,1	20	43,7	19,4
A5	Miftah Nazariyah, Arie Purwa Kusuma & Agus Suyanto, (2020)	30	79,3	9,61	30	72,5	8,67
A6	I Wayan Widana & Ni Made Suryaningsih, (2020)	30	82,3	7,68	30	67,6	6,75
A7	Putri Maisyarah Ammy, (2021)	25	83,2	9,56	25	77,2	10,9
A8	Rahmina & Tasnim Rahmat, (2023)	30	77	17,2	30	69,6	13

Table 2 presents data that will be used in further analysis by finding the effect size and standard error values for each sample. This step will be continued with statistical analysis to provide in-depth results or conclusions. The effect size and standard error values aim to provide a clear and detailed picture of the comparison and significance of each article in this research so that the analysis can be more accurate and informative. The effect size and standard error values for each article that has been analyzed are presented in Table 3.

Table 3. Effect Size and Sample Standard Error

Sample	ES	SE
A1	1,25	0,30
A2	1,31	0,26
A3	1,22	0,26
A4	1,08	0,32
A5	0,73	0,26
A6	2,00	0,31
A7	0,57	0,28
A8	0,47	0,26

Table 3 presents statistical data collected from several articles, including effect size and standard error. A look at Table 3 shows that there was one article with an excellent effect size, three articles with a very high effect size, one article with a high effect size, and three articles with a medium effect size. The statistical data contained in Table 3 was then used to continue the analysis by conducting a series of further statistical tests using JASP software version 0.18. The first test conducted was the publication bias test, which included the use of funnel plots, Egger's test, and the fail-safe N (FSN) test.

Funnel plots can be used to illustrate the test for publication bias visually. In general, it can be said that there is no publication bias if the funnel plot image appears symmetrical, indicating that studies with different effect sizes are evenly distributed around the combined effect value. On the other hand, the presence of publication bias is indicated by a funnel plot image that is not symmetrical, where studies tend to be concentrated on one side or show an uneven distribution pattern. The distribution of effect sizes for each study sample is depicted in the funnel plot image shown in Figure 2. This visualization helps identify whether or not publication bias is present in this analysis.

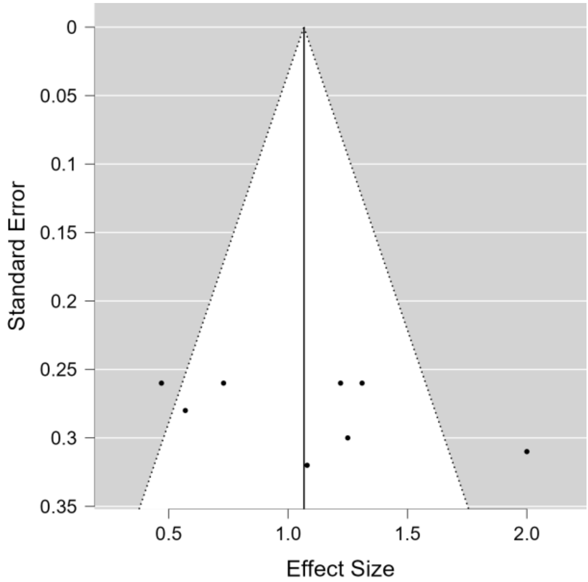

Figure 2. Funnel Plot

The symmetrical distribution on the left and right sides of the effect size distribution can be seen in the funnel plot shown in Figure 2. This shows that there is no publication bias among the primary studies analyzed. However, several publication bias tests, including Eggers's test and fail-safe N, were performed to validate the results demonstrated by the funnel plot. These additional tests guarantee the validity of the results achieved from the initial visual assessment and offer further confirmation.

Table 4. Egger's Test Results

Regression test for Funnel plot asymmetry ("Egger's test")		
	z	**p**
Sei	1.364	0.173

Table 5. Fail-safe N test results

	Fail-safe N	***Target Significance***	***Observed Significance***
Rosenthal	334	0.050	< .001

In Table 4, a p-value of 0.173 was obtained through the use of Egger's Test. This value is higher than the set significance level of 0.05. This result shows that the resulting funnel plot is symmetrical, which indicates the absence of publication bias in the effect size distribution. Therefore, it can be concluded that there is no publication bias in any of the main samples or studies included in this study, so the results of the analysis can be considered free from the influence of such bias.

Table 5 also shows the results of the fail-safe N test, which aims to strengthen the argument that there is no publication bias in this study. Table 5 shows a fail-safe N value of 334. Through manual calculation, using the formula N/(5k+10), where N is the fail-safe N value and k is the number of studies included in the analysis. The calculation resulted in a value of 334/(5 × 8 + 10) = 6.68. This value is greater than 1, indicating that the findings of the studies included in this analysis were not affected by publication bias. This reinforces the belief that there is no publication bias affecting the conclusions drawn from the data, and there is no need to increase or decrease the sample of studies observed.

Next, to obtain a summary effect size of all existing samples, a heterogeneity test was first carried out to determine the level of variation between studies. After that, the appropriate estimation model is selected based on the test results. This heterogeneity test is needed to determine whether the more appropriate estimation model is a fixed effect model or a random effect model. The heterogeneity test results will provide the information needed to make this decision. Table 6 presents the results of the heterogeneity tests, providing a clear picture of the variation between studies and assisting in selecting the most appropriate estimation model to use in subsequent analysis.

Table 6. Heterogeneity Test Results

	Q	**df**	**p**
Omnibus test of Model Coefficients	38.696	1	< .001
Test of Residual Heterogeneity	20.698	7	0.004

Table 6 above shows that the calculated Q value is 20.698, and the p-value obtained is 0.004, which is smaller than the 0.05 significance level. This indicates that the effect size varies significantly among the studies analyzed. In other words, the distribution of effect sizes in this study is heterogeneous. Therefore, the most appropriate effect size estimation model to use in this analysis is the random effects model, as it takes into account the variation between studies and provides more precise estimates under conditions of heterogeneity.

Next, a summary effect size was calculated using a random effects model. This calculation aims to obtain a more accurate estimate of the overall effect size, taking into account the variation between the samples. The effect sizes of each sample, as well as the summary effect resulting from this analysis, are displayed visually in Figure 3 in the form of a forest plot. The figure provides a graphical representation of the individual and overall effect sizes, facilitating interpretation and understanding of how strong and consistent the relationships analyzed across the studies included in this meta-analysis are.

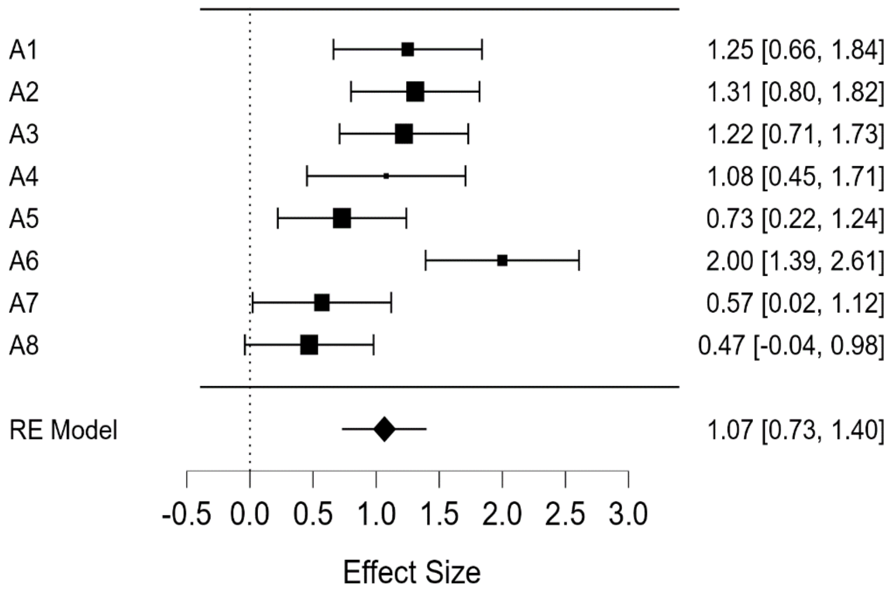

Figure 3. Forest Plot

Table 7. Effect Size Results

Coefficients						
					95% Confidence Interval	
	Estimate	***Standard Error***	***z***	***p***	***Lower***	***Upper***
intercept	1.07	0.171	6.221	< .001	0.730	1.40

In Figure 3 and Table 7 above, it can be seen that the effect size summary shows a value of 1.07 with a lower limit of 0.73 confidence interval and an upper limit of 1.40. This effect size is in the interval $0.75 \leq ES < 1.10$, which indicates that this measure has a high effect size. Furthermore, the hypothesis test will be analyzed and examined in Table 7, where the p-value obtained is less than 0.05. Therefore, it can be concluded that the Reciprocal Teaching model approach has a significant effect on students' mathematics learning outcomes, especially in junior high school students. This shows that the application of this learning approach can effectively improve students' understanding and learning outcomes in mathematics, making a meaningful positive contribution to the student's learning process.

The findings of this research clearly show that the Reciprocal Teaching model significantly influences student learning outcomes in mathematics. The test results produced a p-value of less than 0.05, indicating that the results were statistically significant and supported this conclusion. In the test carried out, an effect size of 1.07 was obtained and was in the interval $0.75 \leq ES < 1.10$, which was classified in the high influence category (Thalheimer & Cook, 2002). These results are in line with other research included in the meta-analysis and found that the Reciprocal Teaching model significantly improved student learning outcomes in mathematics (Ammy, 2022; Apryani et al., 2022; Faidah et al., 2023; Nazariyah et al., 2020; Rahmina & Rahmat, 2023; Saida et al., 2023; Simamora, 2017; Widana & Suryaningsih, 2020). Research results (Pradja & Firmansyah, 2020), which show that the Reciprocal Teaching model helps students increase student motivation, involvement in the learning process, active learning, and mathematical communication skills, support these findings.

To improve student learning outcomes, various innovative learning methods have been developed and tested for their effectiveness. One of the prominent methods in educational research is Reciprocal Teaching. This method helps improve reading skills and shows significant potential in mathematics learning. The study conducted by R. Hidayah et al. (2021) demonstrates that the Reciprocal Teaching model can enhance students' higher-order thinking skills and scientific process skills, emphasizing that the metacognitive strategies applied in learning can help students better understand the material and improve their overall learning outcomes. This research highlights the effectiveness of implementing this model in improving both aspects, namely higher-order thinking skills and scientific process skills, which are critical components in education, including mathematics. This is confirmed by Hattie (2009), who found that one of the best learning models is Reciprocal Teaching, with an effect size of 0.74, significantly influencing student learning outcomes. Vidyasary et al. (2023) suggested that the use of Krulik Rudnick's heuristic strategy in the Reciprocal Teaching model has the potential to improve student learning achievement in mathematics subjects. The results of this study indicate that the Reciprocal Teaching model is an effective learning method for improving mathematics learning outcomes based on the results obtained. This finding is important because it provides evidence from several studies regarding the influence of the Reciprocal Teaching model in mathematics education.

CONCLUSION

Based on the results and discussion, the effect size distribution of all analyzed studies showed no publication bias affecting the overall results of the analysis. This means that the data obtained from various studies can be considered free from publication bias. In addition, the effect sizes from each of the analyzed studies also met the assumption of heterogeneity, which indicates a significant level of variation in the results of the main studies. This variation indicates that there are differences between the studies analyzed, thus providing a strong basis for using an appropriate estimation model, namely the random effects model. Furthermore, the results from the primary study on the effect of Reciprocal Teaching on mathematics learning outcomes showed an effect size of 1.07. This value is within the interval categorized as a high effect size, indicating that the application of the Reciprocal Teaching model influences improving students' mathematics learning outcomes. Thus, it can be concluded that there is a significant influence between the application of the Reciprocal Teaching model on improving students' mathematics learning outcomes.

It is important to remember that although this analysis shows that the Reciprocal Teaching model greatly influences student mathematics learning outcomes, this conclusion is only based on studies that produce sufficient information to calculate an effect size. Some related studies were not included in this analysis because they did not meet the inclusion criteria set for this study or because no statistical data was available. Thus, it is possible that the conclusions obtained from this research cannot adequately convey the effect size of the Reciprocal Teaching model on student mathematics learning outcomes. Further research using a larger sample size and a wider variety of studies is needed to gain a more comprehensive understanding.

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