IDENTIFICATION OF EFFECTIVENESS MEASUREMENTS AND BIAS PUBLICATION OF LITERATURE RESULTS STUDY: A COOPERATIVE LEARNING MODELS ON MATHEMATICS LEARNING OUTCOMES OF VOCATIONAL SCHOOL STUDENTS IN INDONESIA

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ABSTRACT

This meta-analysis intends to determine the impact of cooperative learning model research findings on the mathematics learning outcomes of Indonesian vocational high school students. Based on moderator variables, such as grade level and student sample size, identify efficacy and publication bias measures. Data from descriptive analysis, which included the mean, standard deviation, and sample size, were collected from 21 research projects based on applying the cooperative learning model in the experimental group and direct learning in the control class. Forest plot analysis was the data analysis method used. The results of the measure of the effectiveness of the cooperative learning model on mathematics learning outcomes in grades 10 and 11 were 0.87 and 0.92, with each effect size category being medium. While the effectiveness of the learning model is measured using a sample size of 1 to 30 students, and more than 30 students were 0.94 and 0.83, respectively, each has a medium effect size category. The results of other analyses show no publication bias. The findings of this study provided teachers with information on how to apply effective cooperative learning models to mathematical learning outcomes in 10th and 11th grade and the efficiency of learning with large class size.

KEYWORDS

Cooperative learning model, mathematics learning outcomes, meta-analysis, forest plot, publication bias

HOW TO CITE

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Highlights

- *Cooperative learning has a moderate but significant effect on student mathematics learning results.*
- *The forest plot shows the meta-analysis sample's adequacy by identifying publication bias.*
- *This meta-analysis shows the application of effective cooperative learning to mathematics learning outcomes based on grade level and sample size.*

INTRODUCTION

Teachers' application in student-centred learning is a barrier for certain Indonesian teachers in giving students a thorough comprehension of the topic. Research by Bjork (2013) used a sample of teachers in Indonesia, as many as 100 high school teachers who participated in filling out a questionnaire related to the implementation of learning activities by teachers. The results showed that 53% of respondents in learning activities by teachers to students used the lecture method. Direct learning activities include up to 20% of respondents while learning by involving students in discussions includes up to 5%. Furthermore, traditional learning approaches are used, which are teacher-centred and emphasise memorisation (Bjork, 2013). The teacher's learning process only emphasises students on memorising and learning focuses a lot on the material compared to evaluating and synthesising material according to its true meaning (Rodzalan and Saat, 2015; Wijaya et al., 2019). Teachers' learning activities are repetitive and yet dominated by the lecture technique. The teacher sees learning activities with the lecture method as easier conveying the material, although it generally makes students more passive and has difficulty thinking critically (Baguma et al., 2019; Mustofa and Yuwana, 2016). Another difficulty of teachers in South Sulawesi, one of the provinces in Indonesia, in carrying out the learning process by applying critical thinking learning is influenced by the lack of students' basic understanding of mathematics, interest, and motivation to learn mathematics (Ridwan et al., 2022).

Lesson designs, quality learning processes, and assessment and evaluation of learning outcomes are all significant because of the instructors, as mentioned above' learning phenomena. Compared with teacher-centred learning, one of the learning approaches significantly influences learning outcomes and the development of other aspects of students in cooperative learning. The cooperative learning model can improve learning outcomes, social skills, responses, and student learning activities (Ismail et al., 2019) and develop 21st-century collaboration, creativity, critical thinking, and communication (Lai and Viering, 2012). To develop these skills, educational institutions need to consider using innovative learning methods to increase student enthusiasm for learning and provide opportunities for active learning (Saavedra and Opfer, 2012). One of these innovative learning methods uses a cooperative learning model that requires students to work in groups to share ideas and materials to achieve a common goal of understanding the material.

The cooperative learning process involves students working in small heterogeneous groups conducting constructive discussions to help each other and provide understanding to other students (Johnson and Johnson 2014; Johnson, Johnson and Smith, 2014; Slavin, 1989). Studies on cooperative learning have shown that when students work together, they learn more than working alone (Johnson and Johnson, 2014; Slavin, 2014). In addition, research by Slavin (1989) by conducting learning on the same material content shows that the cooperative model is effective compared to conventional learning. The results of research using a meta-analysis approach also show that student-centred cooperative learning models are more effective than teacher-centred conventional learning (Agustini et al., 2021; Capar and Tarim, 2015; Kalaian and Kasim, 2014; Kumar, 2017; Kyndt et al., 2013). The measurable variables in the study consisted of learning outcomes and social and emotional skills.

Several researchers have conducted a meta-analysis evaluation of cooperative learning utilising moderator factors at all levels of education so far (Capar and Tarim, 2015; Hattie, 2009; Mansurah et al., 2021; Setiana et al., 2020; Sharan, 2010; Turgut and Turgut, 2018) as well as on student learning outcomes, with a focus on cognitive and emotional development (Parveen, Yousuf and Mustafa, 2017; Ridwan et al., 2021; Vega and Hederich, 2015). In comparison to the tertiary level, Hattie (2009) found that the cooperative learning approach for elementary and high school students was appropriate. Meanwhile, research by Capar and Tarim (2015) showed that cooperative learning is most effective at the tertiary level. Then, Mansurah et al.'s (2021) research showed that the cooperative model of the Two Stay Two Stray type at the high school level had a more significant effectiveness measure than the elementary and junior high school levels. Furthermore, compared to learning in elementary and junior high schools, the cooperative learning approach had the largest significant effect size of 0.445 on high school students' mathematics learning outcomes. However, other studies show that learning with cooperative models does not significantly affect mathematics learning outcomes based on each variable at the elementary school, junior high school, high school, and college level (Setiana et al., 2020; Turgut and Turgut, 2018).

Researchers are still utilising meta-analysis to discover measurements of the impact of cooperative learning models on vocational high school students' mathematics learning results. Identifying the learning effectiveness measure is based on the grade level variable of grades 10 and 11. Another variable is the sample size consisting of 1 to 30 and more than 30 students who become the research sample. In addition, another identification is the publication of bias against the research study sample used in the meta-analysis to see the adequacy of the research study sample to identify measures of the learning effectiveness of the cooperative model. The study literature search was conducted using Google Scholar and the criteria of a sample of research articles published in Google Scholar, SINTA (Science and Technology index), and GARUDA (Garda Reference Digital)-indexed publications. The samples for the research study were divided into two groups based on descriptive data analysis results based on cooperative learning models in the experimental class and traditional learning in the control class. The results of the descriptive data analysis consist of the sample size, standard deviation, and the average learning outcomes of mathematics for the two learning applications. Then, using the findings of a meta-analysis utilising forest plot analysis with a fixed-effect and a random-effect model, determine the effectiveness of the cooperative learning model. Meanwhile, the funnel plot approach, regression method, and rank correlation, as well as the Fail-Safe *N* method, were used to detect publication bias.

MATERIALS AND METHODS

Research Designs

This research employs a meta-analysis approach to uncover efficacy and publication bias measures in research studies on the impact of cooperative learning on mathematics learning outcomes among Indonesian vocational high school students. A meta-analysis is a statistical tool for synthesising a group of research studies that answer the same research issue (Borenstein et al., 2009; Glass, McGaw and Smith, 1981). The statistical method synthesised this quantitative research by summarising and comparing research results. In contrast to other synthetic studies, meta-analysis focuses on study findings to develop conclusions based on effect sizes (Card, 2012). According to Field and Gillett (2010), meta-analysis procedures include (1) conducting a literature review to formulate a problem, (2) setting inclusion/exclusion criteria, (3) calculating effect sizes for each research study, (4) conducting a meta-analysis, (5) identifying moderator variables with further analysis, (6) conducting a publication bias analysis, and (7) writing down research study results.

Research Procedure

The stages of meta-analysis in this study consist of problem formulation by identifying the effectiveness of cooperative learning on the mathematics learning outcomes of vocational high school students. Identification consists of measures of effectiveness and publication of bias towards research studies that meet the criteria used as samples in the meta-analysis. Search research study literature using the keywords "(effectiveness or effect) of cooperative learning on mathematics learning outcomes of vocational high school students" through Google Scholar by considering the criteria for journals or seminars based on the Google Scholar, SINTA or GARUDA index. The grouping of research studies based on the criteria of independent variables consisted of cooperative learning in the experimental group and conventional learning in the control class. At the same time, the dependent variable is the mathematics learning outcomes of vocational high school students. Another criterion is a research study that employs a quasi-experimental research design. Then, the grouping results of research studies were evaluated based on the data from the descriptive analysis of the application of the two lessons consisting of the sample size, standard deviation, and mean. The criteria for grouping the literature study are given in the PRISMA diagram in Figure 1.

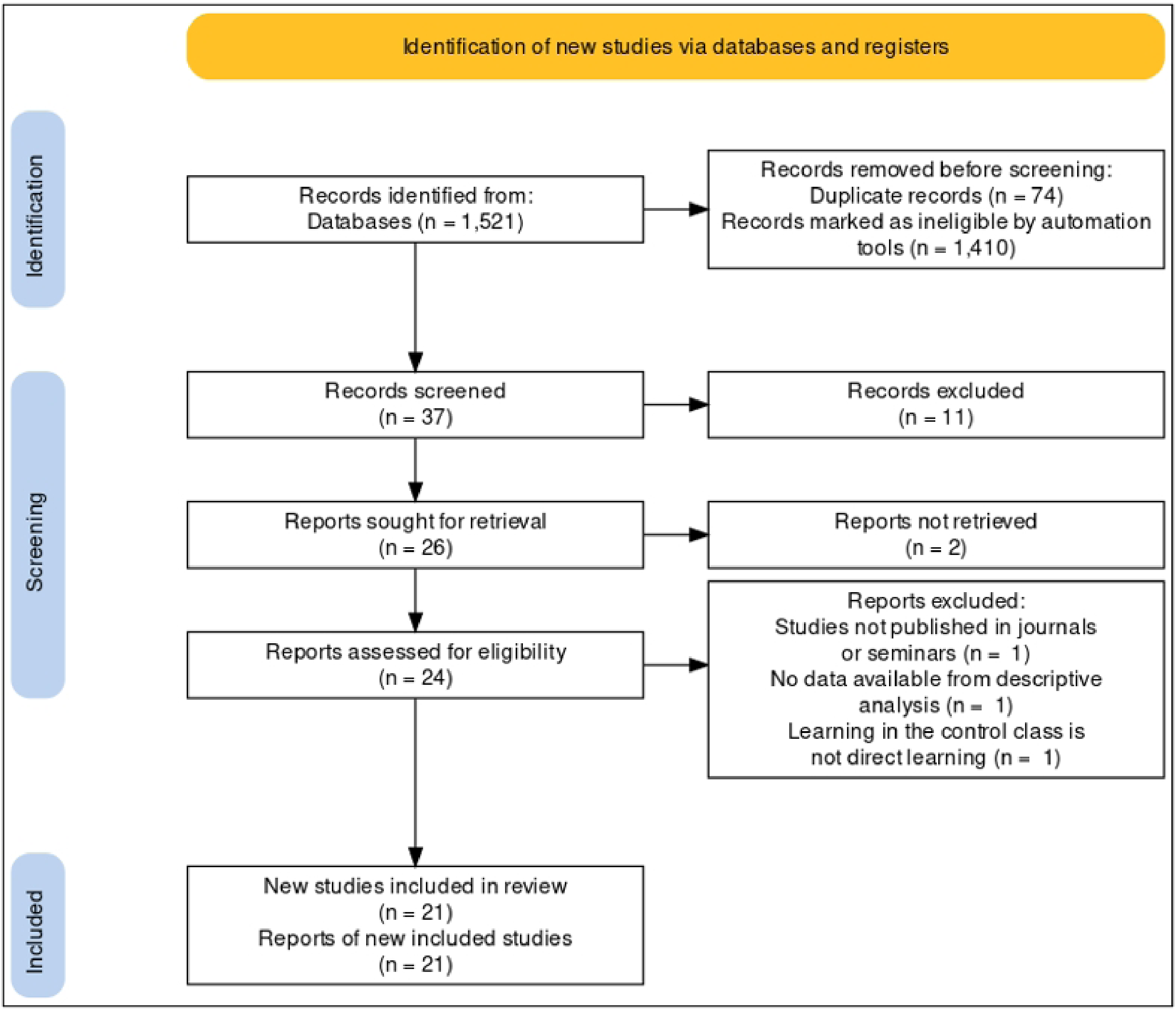

Figure 1: PRISMA diagram – the process of grouping research studies (Page et al. 2021)

For further information, go to http://www.prisma-statement.org/. The results of descriptive data analysis for the two groups of learning applications for each research study are then grouped and coded based on the author's name and year of research and the results of descriptive data analysis for the two groups of learning applications for each research study. The last stage is a meta-analysis based on moderating variables using descriptive analysis data for each research study that meets the criteria of heterogeneity test, forest plot analysis, funnel plot analysis, and publication bias analysis.

Data Analysis

The data analysis technique used in this research is meta-analysis using forest plot analysis and funnel plot analysis using Trim and Fill methods. The efficiency of the two learning models on the dependent variable was investigated using forest plot analysis. The effect size criteria are as follows on values of 0.00–0.20: weak, 0.21–0.50: small, 0.51–1.00: medium, and greater than 1.01: large (Cohen, Manion and Morrison, 2007). Identification of differences in effectiveness measures using the summary effect size estimation value based on the *p*-value obtained from the estimated value of *z* with $p = 2 \times \left[1 - \Phi(|z|)\right]$ where $\Phi(|z|)$ is the standard cumulative normal distribution. The value of $\Phi(|z|)$ can be calculated using Microsoft Excel with the function "=NORMSDIST(*z*)". Then, for the estimated value of z, it is obtained using the formula $z = \frac{M}{SE_M}$, where M and S_{EM} represent the value and standard error of the summary effect size, respectively. For example, given the following operational hypothesis:

- H0 states that there is no difference in the size of the effectiveness of the cooperative and direct learning model on the mathematics learning outcomes of vocational high school students,
- H1 states a difference in the effectiveness of the two learning models on the mathematics learning outcomes of vocational high school students.

For the hypothesis testing criteria above, if the *p*-value is less than 0.05, it rejects H0 so that there is a difference in the effectiveness of the two learning models (Retnawati et al., 2018). The funnel plot analysis was then utilised to discover publication bias in the meta-analysis' research articles. According to Card (2012), identifying biased publications can use the results of funnel plot analysis using the Trim and Fill method. If each effect size is distributed symmetrically in the funnel plot, there is no publication bias in the study (Borenstein et al., 2009; Cooper, 2016). The form of the funnel plot, on the other hand, indicates publication bias if it is asymmetrically distributed.

Other publications identified bias in this study using the regression method (Egger et al., 1997) and the rank correlation method (Begg and Mazumdar, 1994), and the Fail-Safe *N* (FSN) method (Rosenthal, 1979). Testing the null hypothesis based on a symmetric funnel plot using *p*-value criteria in the regression method and rank correlation. If the *p*-value is greater than or equal to 0.05, it means that the funnel plot is symmetrical so that there is no publication bias. The FSN value, which results from statistical calculations, serves as the basis for the Fail-Safe *N* method's criterion. If the FSN value is more significant than $5k + 10$ with k indicating the number of research studies observed, then the sample of these research studies is not indicated by publication bias (Mullen, Muellerleile and Bryant, 2001).

RESULTS

The literature study results obtained 21 research studies, consisting of 16 studies published in journals and five others in proceedings. The eleven research projects were then published in SINTA and GARUDA-indexed publications, while the others were published in Google Scholar-indexed journals and conferences. The moderator variables in this meta-analysis study are dependent on the grade level, and student sample size used. The cooperative learning model in grade 10 consists of 15 research studies, and the others are research studies with learning in grade 11. Then, 13 research studies are using a sample size of 1 to 30 students, while others use more than 30 students. Data analysis used a meta-analysis approach based on data from descriptive analysis consisting of the mean, standard deviation, and sample size based on grade level variables and the sample size used in the research study.

The preliminary analysis conducted a heterogeneity test to identify the variability of the research study sample used in the meta-analysis. Identification of variability aims to see the effect of the effect size based on sampling error or is also influenced by population variance. The heterogeneity condition in the meta-analysis approach refers to sampling error or variation in results between independent studies (Borenstein et al., 2009). The results of heterogeneity testing also provide information on determining the effect model used in the follow-up analysis consisting of a fixed-effect model or a random effect model. The analysis of heterogeneity testing in this study uses parameters based on the analysis of *Q*-statistical calculations with *p*-values given in Table 1.

Moderator	Variables	*Q*-Statistik		
		value	*df*	*p*-value
Grade	10	34.51	14	0.0017*
	11	11.03	5	0.0507
Sample Size	1 to 30	17.57	12	0.1294
	more than 30	27.02	7	0.0003*

*Note. *p-value <0.05*

Table 1: Results of heterogeneity test analysis

Table 1 shows the results of the heterogeneity test analysis of research studies based on numerical information data on the application of cooperative learning models in the experimental class and conventional in the control class to the mathematics learning outcomes of vocational high school students. The analysis of the heterogeneity test using the value of the *Q*-statistical parameter for the learning variable in class 10 and a sample size of more than 30 students each obtained a Q value > df. The corresponding *p*-value for $Q = 34.51$ (respectively 27.02) is 0.0017 (respectively 0.0003), each of which is less than 0.05. It shows that the sample data used in the meta-analysis satisfy heterogeneous conditions, so the effect size is affected by sampling error and population variance. However, the research study's sample data met the homogeneity of other variables, with sampling error being the only factor. Furthermore, according to Ellis (2010), for the distribution of data that meets the heterogeneous assumption, it uses a random-effects model and vice versa. If it fulfils the homogeneous assumption, it uses a fixed-effects model. As a result of the heterogeneity test in Table 1, the learning variable in grade 10 was heterogeneous. In addition, the research study with a sample size of more than 30 students met the heterogeneity assumption. As a result, to determine the effect size of each research study and the summary effect size, the effect model employed for subsequent analysis is a random effect model. At the same time, the other variables use a fixed-effect model for further analysis based on forest plot analysis.

Forest plot research shows how cooperative and traditional learning strategies affect vocational high school students' mathematics learning outcomes. The forest plot shows the summary results of the meta-analysis in the form of visualisation (Borenstein et al., 2009; Card, 2012). The forest plot described for each research study result is illustrated as a forest that gathers to form a forest to provide a synthetic picture (San and Kis, 2018). The forest plot component consists of information on researcher data and year of study, effect sizes with lower and upper bounds for each research study, and summary effect size information with lower and upper bounds obtained using the random-effects model or fixed-effect model. The forest plot also provides weight information for each effect size and a summary effect. The effect size plots and standard errors for each research paper utilised in the meta-analysis using JASP software are displayed in Figures 2 and 3 due to the forest plot analysis.

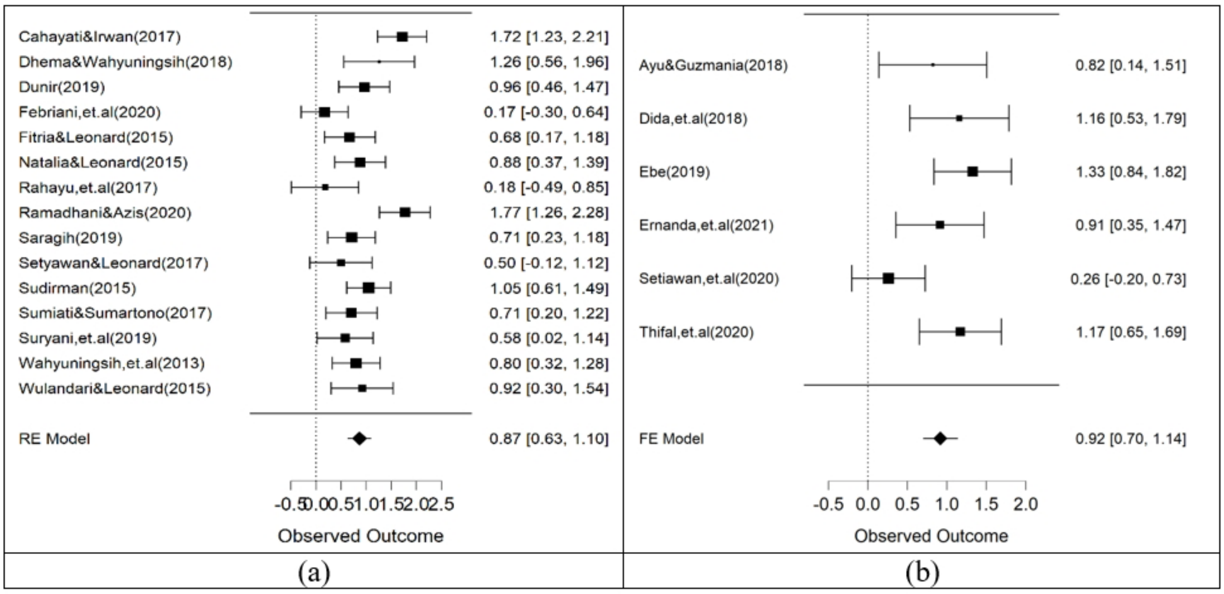

Figure 2: Forest plot of effect size data based on grade level (a) 10 (b) 11

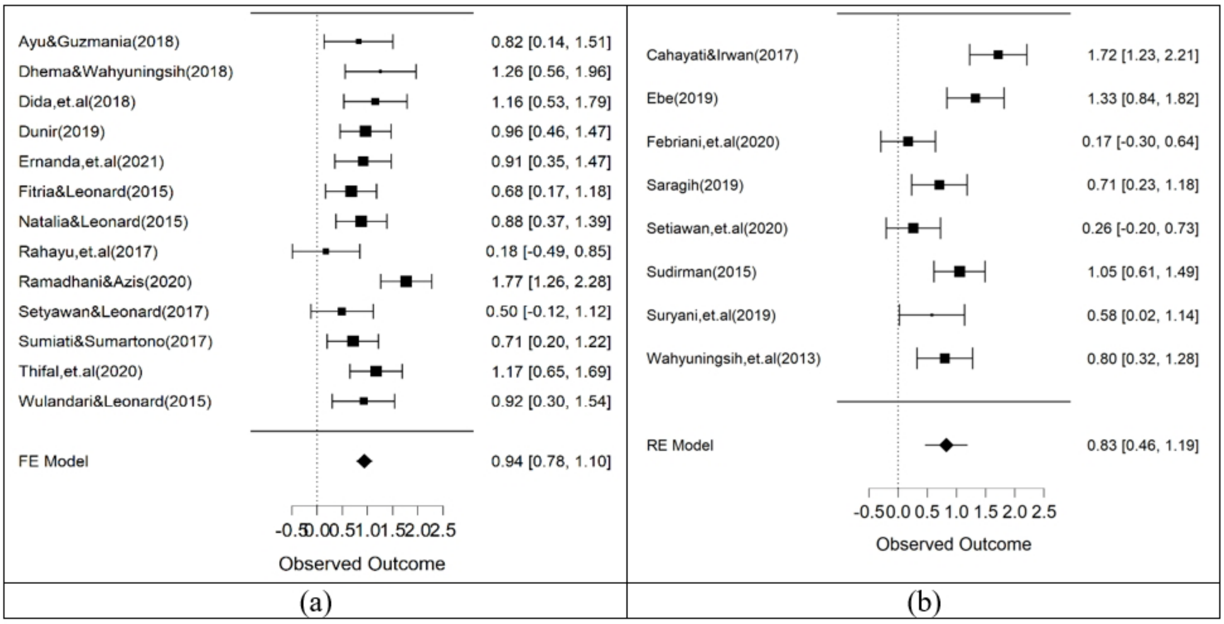

Figure 3: Forest plot of effect size data based on sample size (a) 1 to 30 (b) more than 30 students

Figures 2 and 3 show the results of the forest plot analysis using the random-effects model (Figures 2(a) and 3(b)) or the fixed-effects model (Figures 2(b) and 3(a)). The forest plot results consist of effect sizes with lower and upper bounds for each research study and summary effect sizes. The effect size depicts the effectiveness of cooperative learning on vocational high school students' mathematics learning outcomes. The effect size plots for each research study based on grade level and sample size variables show an effect size value greater than zero. It demonstrates that cooperative learning impacts vocational high school students' mathematics learning outcomes compared to traditional learning. The measure of the effectiveness of the summary of cooperative learning at the 10th-grade level is 0.87 [95%-CI: 0.63;1.10], therefore, according to Cohen, Manion and Morrison (2007), the effect size shows the medium category. According to the fixed effects model, learning in grade 11 is another moderator variable with a 0.92 [95%-CI: 0.70;1.14] effect size in the medium category. Meanwhile, cooperative learning based on the sample size variable uses 1 to 30 students and more than 30 students, respectively, the medium effect size is 0.94 [95%-CI: 0.78;1.10] and 0.83 [95%-CI: 0.46;1.19]. The forest plot results also suggest that cooperative learning positively impacts vocational high school students' mathematics learning outcomes compared to conventional learning.

The results of other forest plots in Figures 2 and 3 also show that for each study sample, the research used in the meta-analysis had a statistically significant effect or not on the summary effect size. For research studies that do not have a statistically significant effect, it can be identified based on a 95% confidence interval containing zero. Therefore, based on the class level variables and the sample size used in the research study, Febriani et al. (2020), Rahayu, Murni and Sakur (2017), Setiawan, Susilowati and Farahsanti (2020), and Setyawan and Leonard (2017) provide a statistically insignificant effect that pulls the summary effect size towards the zero line. It shows that the three research studies provide statistical information that learning using the cooperative model tends to be less effective in improving the mathematics learning outcomes of vocational high school students. Meanwhile, other research studies have effect sizes with non-zero confidence intervals to be consistent with each other and affect the summary effect size.

Based on grade level features and the sample size used in learning, the findings of the forest plot analysis may be used to uncover differences in the effectiveness of cooperative and traditional learning models on the mathematics learning outcomes of vocational high school students. Identifying these differences is based on calculating the estimated summary effect size value and the *z*-value with the *p*-value. The results of calculating the estimated value are given in Table 2.

Moderate Variables		EV	95%-CI	SE	*z*-value	*p*-value
Grade	10	0.87	[0.63; 1.10]	0.12	7.20	< 0.001*
	11	0.92	[0.70; 1.14]	0.11	8.12	< 0.001*
Sample Size	1 to 30	0.94	[0.78; 1.10]	0.08	11.73	< 0.001*
	more than 30	0.83	[0.46; 1.19]	0.19	4.46	< 0.001*

*Note. EV=Estimated Value; SE=Standard Error; *p-value<0.05*

Table 2: The results of the analysis of calculating the estimated value of the summary effect size

Table 2 shows the analysis of calculating the estimated summary effect size value based on moderator variables consisting of cooperative and conventional learning models at the grade level and the sample size used in research studies using fixed-effects and random-effects models. Based on the *p*-values for each grade level variable and sample size in Table 2, each obtained *p*-value < 0.001, which indicates rejecting H_0. It shows differences in the size of the effectiveness of learning with cooperative and conventional models on the mathematics learning outcomes of vocational high school students based on the level variable and the number of students in the class. Other results show that each moderator variable's summary effect estimation value does not contain zero at the 95% confidence interval. According to Springer, Stanne and Donovan (1999) and Israel and Richter (2011), the confidence interval for zero measurements showed insignificant results. It shows that the cooperative learning model based on grade level variables and sample size each significantly affects the mathematics learning outcomes of vocational high school students.

Following that, conditions for publication bias were found using the research studies involved in the meta-analysis. The condition of publication bias can refer to the possibility of finding the results of research studies that do not have a statistically significant effect or have a significant effect but are contrary to theory construction in general. The term "publication bias" refers to a situation in which each research study included in a published meta-analysis does not systematically represent the population studied (Rothstein, Sutton and Borenstein 2005). The analysis to identify publication bias in this study was based on visual funnel plot analysis using the Trim and Fill model, rank correlation and regression methods, and the Fail-Safe *N* method.

Trim and Fill models for funnel plots use an iterative technique to eliminate research studies with small sample sizes that significantly impact the funnel plot's positive side. The iterative procedure involves recalculating the effect size for each iteration to form a symmetric funnel plot. The funnel plots in Figures 4 and 5 using the Trim and Fill method use a fixed-effect model and a random effect model based on the analysis results of calculating effect sizes and standard errors for each research study used in the meta-analysis. Figure 3 depicts the funnel plot results based on the analysis of calculating effect sizes and standard errors for each research study based on mathematics learning outcomes of vocational high school students utilising cooperative and conventional models in grades 10 and 11. A visual study of effect size distribution is conducted inside or outside the pyramid to discover any publications. The effect sizes are dispersed in the middle and top of the pyramid if there are research studies outside it. Publication bias is discovered when most research studies are dispersed towards the bottom of the funnel plot graph or only in one vertical line area (Borenstein et al., 2009).

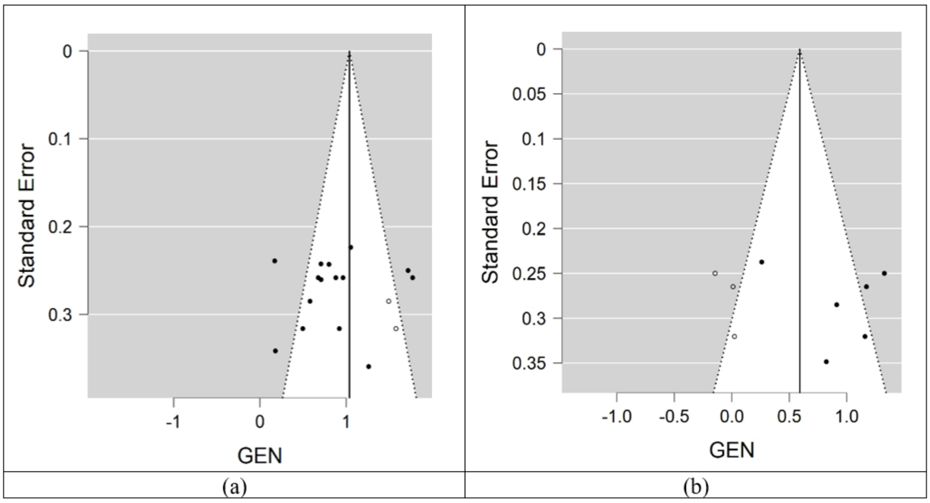

Figure 4: Funnel plot of effect size data based on grade level (a) 10 (b) 11

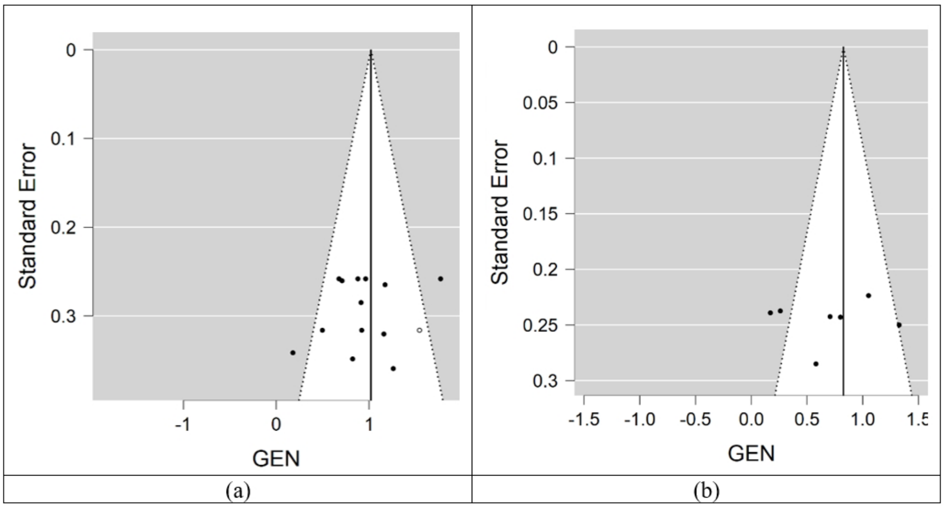

Figure 5: Funnel plot of effect size data based on sample size (a) 1 to 30 (b) more than 30 students

The results of the funnel plot analysis in Figures 4 and 5 show that the effect sizes are visually distributed symmetrically around a vertical line consisting of closed or open circles contained in a pyramid. Even if several research studies in Figures 4(a) and 5(a) have a closed circle on the exterior and are near the bottom of the pyramid, these results show no publishing bias.

The regression method examines the linear relationship between the estimated intervention effect and the standard error (Egger et al., 1997), while the rank correlation method examines the relationship between the estimated intervention effect and variance in sampling (Begg and Mazumdar, 1994). The *p*-value, which produces an asymmetric funnel plot graph so that publication bias does not indicate the sample utilised in the study, is used to identify publication bias using both approaches. Table 3 summarises the findings of the JASP (Jeffreys's Amazing Statistics Program) tool's calculation study of the two techniques.

Moderate	Variables	Regression Method		Rank Correlation Method	
		Regression Coefficient	*p*-value	Correlation Coefficient	*p*-value
Grade	10	-0.531	0.595	-0.099	0.616
	11	0.896	0.370	-0.200	0.719
Sample Size	1 to 30	-1.161	0.246	-0.067	0.756
	more than 30	0.049	0.961	0.255	0.383

Table 3: The results of analysis using the regression method and rank correlation

Table 3 shows the results of the calculation analysis using the regression method and rank correlation to identify publication bias based on the research study sample used in the meta-analysis. Identification of publication bias based on research papers on learning outcomes of vocational high school students utilising cooperative and conventional models on mathematical learning outcomes using grade level variables and sample sizes utilised in learning. The regression coefficients show that the cooperative learning model in grade 11 and using more than 30 students have a positive value of 0.896 and 0.049, respectively. With a sample size of more than 30 students, the coefficient utilising rank correlation for the cooperative model learning variable was 0.255. The results of the regression coefficients and other rank correlations obtained negative values indicating the results of the research studies used in this study using a dominantly small sample size. The results of other analyses using the two methods obtained a *p*-value greater than 0.05 for each moderator variable, which shows an asymmetric funnel plot graph with no publication bias. Research by Setiana et al. (2020) also identified publication bias using the regression method and rank correlation. The results of the two methods respectively obtained regression and correlation coefficients of 0.683 and 0.247 with *p*-values greater than 0.05. The findings also suggest no evidence of publication bias in the meta-analysis' study articles.

Moderate	Variables	*k*	FSN	5*k* + 10	Target Significance	Observed Significance
Grade	10	15	851	85	0.050	< 0.001
	11	6	143	40	0.050	< 0.001
Sample Size	1 to 30	13	623	75	0.050	< 0.001
	more than 30	8	261	50	0.050	< 0.001

Table 4: Analysis results of file drawer

Table 4 shows the FSN scores for each moderator variable consisting of cooperative learning in grades 10 and 11 and using a sample size of 1 to 30 students and more than 30 students. The FSN values for each moderator variable are greater than $5k + 10$, with k representing the number of research studies used in the meta-analysis. According to Mullen, Muellerleile and Bryant (2001), these requirements imply that the meta-analysis research study sample does not contain biased publications. It suggests that there is no potential publication bias in learning effectiveness with a cooperative model on the mathematics learning outcomes of vocational high school students depending on the level variable and the number of students in the class. Furthermore, each FSN value denotes the number of research studies that should be included in the meta-analysis to reduce the likelihood of publication bias.

DISCUSSION

Researchers' meta-analysis study of the impact of learning with cooperative models on the mathematics learning outcomes of vocational high school students is still relatively small. The meta-analysis study uses data from identifying research results conducted in Indonesia. So that the results of the meta-analysis review obtained only contribute information to the scope of the Indonesian state. Nonetheless, this study's results were compared with those of several relevant studies conducted in several countries. A meta-analysis study on cooperative learning has been carried out by Capar and Tarim (2015) and Turgut and Turgut (2018), with each dependent variable being data on student mathematics learning outcomes in Turkey. The same research study was also conducted by Xie, Wang and Hu (2018) and Setiana et al. (2020) to identify the effect of cooperative learning models on student learning outcomes in China and Indonesia. While research by Mansurah et al. (2021) and Ridwan, Hadi and Jailani (2022) also identified the effectiveness of the cooperative learning model on student learning outcomes in Indonesia.

Identifying the effectiveness measure of the cooperative learning model in this study is based on the variable level and the number of students in the class. The effect size of the summary of cooperative learning at the 10th and 11th-grade levels was 0.86 and 0.92, respectively, in the medium effect size category. Meanwhile, cooperative learning based on the sample size variable uses 1 to 30 students and more than 30 students, respectively, the medium effect sizes are 0.93 and 0.81. So far, research with a meta-analysis approach uses the variables of education level, the field of study, culture, mathematics, cooperative learning techniques used, and duration in learning mathematics (Capar and Tarim, 2015; Mansurah et al., 2021; Setiana et al., 2020; Turgut and Turgut, 2018).

Capar and Tarim's (2015) research use moderator variables based on education level, mathematics field, cooperative learning techniques used, duration of mathematics learning, and mathematics learning outcomes. The results of the measurement of the effectiveness of learning with the cooperative model show that it is most effective at the tertiary level with an effect size of 1.33, while at high school in the medium category, it is 0.54. Then, research by Mansurah et al. (2021) used moderator variables based on subjects consisting of mathematics, natural sciences, and social sciences. The other variables are based on elementary, junior high, and high school levels. The results showed that learning using the Two Stay Two Stray cooperative model effectively measured 0.558 at the high school level. The results of research by Ridwan, Hadi and Jailani (2022) also show that the effectiveness of cooperative learning on mathematics learning outcomes for middle school students is 0.89 with a medium effect size category. In addition, the learning model also affects the mathematics learning outcomes of high school students with an effect size of 0.445. The same result was also obtained by Xie, Wang and Hu (2018), showing that the cooperative learning model has a significant effect on improving mathematics learning outcomes with a medium effect size of 0.67. However, the research results by Setiana et al. (2020) show that learning with a cooperative model has a weak effect on students' mathematics learning outcomes for all levels of education. Furthermore, the findings of a meta-analysis review by Turgut and Turgut (2018) demonstrate that cooperative learning has no significant impact on mathematics learning outcomes when variables at the elementary, junior high, high school, and college levels are taken into account.

Another result of the analysis is identifying publication bias against the research studies used in the meta-analysis. Identification uses funnel plot analysis, regression, rank correlation methods, and the FSN method. The results of the funnel plot analysis in Figures 4 and 5 show that the effect sizes are visually symmetrically distributed around the vertical line in the funnel plot. Based on the visual analysis of the effect size on the funnel plot, this condition indicates no publication bias. However, because the funnel plot identification results are subjective, they cannot demonstrate publication bias in the research study population. Therefore, identifying other biased publications uses the regression and rank correlation and FSN methods.

The regression method's identification results and rank correlation in Table 3 show that a *p*-value greater than 0.05 was obtained for each moderator variable. Thus, an asymmetric funnel plot is shown, so there are no biased publications. The results of other identification methods in Table 4 show that the FSN value of 851 is more significant than $5k + 10 = 85$. It shows that research studies on the effectiveness of learning with cooperative models on mathematics learning outcomes of vocational high school students in grade 10 are free from publication bias. The other moderating variables also show a higher FSN value of $5k + 10$, with k representing the number of research studies. These conditions indicate research studies related to the effectiveness of cooperative learning on the mathematics learning outcomes of vocational high school students based on grade level variables and sample sizes free from publication bias conditions.

Moreover, the meta-analysis review by Mansurah et al. (2021) identified publication bias using three methods: funnel plot analysis, rank correlation and regression methods, and the FSN method. Identification of publication bias against research studies related to the effectiveness of learning the Two Stay Two Stray type of cooperative model on student learning outcomes. The funnel plot analysis results were visually carried out based on the condition of the open and closed circles in the funnel plot. The results of the rank correlation and regression methods also use a comparison of *p*-values with a significance level of 0.05 and the FSN method by comparing the FSN value and the equation value of $5k + 10$. Both methods also show no publications. Then, Setiana et al. (2020) identified biased publications based on research studies on the effect of cooperative learning models on students' mathematics learning achievement. Identification of publications also uses funnel plot analysis and Rank and Regression correlation methods. Funnel plot analysis is done visually by comparing plot results based on conditions before and after using the Trim and Fill models. Then the rank correlation and regression methods results also show that research studies are free from publication bias, which also compares *p*-values with significance levels. It suggests that a meta-analysis review by Mansurah et al. (2021) and Setiana et al. (2020) also showed no indication of publication bias towards the research studies used in the meta-analysis.

CONCLUSION

This study's meta-analysis technique shows that the cooperative learning model positively impacts the mathematics learning outcomes of Indonesian vocational high school students. The effectiveness of learning with cooperative models on mathematics learning outcomes in grades 10 and 11 are 0.87 and 0.92, respectively, in the medium category. Learning with the cooperative model also provides an effect size based on the sample size used in the study, which is 1 to 30 students and more than 30 students each of 0.94 and 0.83 also in the medium category. The results of other analyses using the funnel plot method, the regression method and rank correlation, and the Fail-Safe *N* method show no indication of publication bias for each moderator variable. It demonstrates that the meta-analysis included a sample of research studies in determining the impact of cooperative learning methods on vocational high school students' mathematics learning results. This study provides information to teachers regarding the application of effective cooperative learning models to mathematics learning outcomes at the 10th and 11th-grade levels and the efficiency of learning to the number of students in the class. Then, the limitation of this research is the grouping of research studies only in the scope of Indonesia and based on vocational high school-level variables. Another limitation is the numerical information results based on descriptive data analysis of research studies used in the meta-analysis published in journals indexed by Google Scholar, GARUDA, and SINTA index. As a result, more research is needed to use the findings of research studies, considering the journal's international scope and credibility, and other moderating variables like education level, mathematics field, cooperative learning techniques used, and length of time spent learning mathematics.

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APPENDIX

RESULTS OF GROUPING RESEARCH STUDY DATA

Researcher and Year	Access of Journal
Ayu and Gusmania (2018)	https://www.journal.unrika.ac.id/index.php/jurnalphythagoras/article/view/1319
Cahayati and Irwan (2017)	http://jurnal.una.ac.id/index.php/jmp/article/view/122
Dhema and Wahyuningsih (2018)	http://jurnal.ikipmumaumere.ac.id/index.php/birunimatika/article/view/95
Dida et al. (2018)	http://jurnal.ikipmumaumere.ac.id/index.php/birunimatika/article/view/8
Dunir (2019)	http://jurnalmandiri.com/index.php/mandiri/article/view/62
Ebe (2019)	https://www.ejournal.lppmunidayan.ac.id/index.php/fkip/article/view/292
Ernanda et al. (2021)	https://www.journal.unrika.ac.id/index.php/jurnalphythagoras/article/download/3127/pdf
Febriani et al. (2020)	https://proceeding.unikal.ac.id/index.php/sandika/article/view/414
Fitria and Leonard (2015)	https://journal.lppmunindra.ac.id/index.php/repository/article/view/2409
Natalia and Leonard (2015)	https://journal.lppmunindra.ac.id/index.php/repository/article/view/2394
Rahayu et al. (2017)	https://jom.unri.ac.id/index.php/JOMFKIP/article/view/12482
Ramadhani and Azis (2020)	http://jurnal.umsu.ac.id/index.php/jmes/article/view/4025
Saragih (2019)	http://jurnal.una.ac.id/index.php/jd/article/view/642
Setiawan et al. (2020)	https://jurnal.radenwijaya.ac.id/index.php/PSSA/article/view/196
Setyawan and Leonard (2017)	https://journal.lppmunindra.ac.id/index.php/repository/article/view/1954
Sudirman (2015)	https://gemawiralodra.unwir.ac.id/index.php/gemawiralodra/article/view/118
Sumiati and Sumartono (2017)	https://ejournal.unitomo.ac.id/index.php/mipa/article/view/452
Suryani et al. (2019)	https://www.journal.unrika.ac.id/index.php/jurnalphythagoras/article/download/2011/1435
Thifal et al. (2020)	https://jurnal.ustjogja.ac.id/index.php/union/article/view/8062
Wahyuningsih et al. (2013)	https://ojs.unud.ac.id/index.php/jmat/article/view/16568
Wulandari and Leonard (2015)	https://journal.lppmunindra.ac.id/index.php/repository/article/view/2503